Westfield, NJ

Pavement Management Analysis Report

December 2019

Town of Westfield, NJ
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1.0 EXECUTIVE SUMMARY & RECOMMENDATIONS

Project Summary

In 2019 IMS Infrastructure Management Services, LLC (IMS) was contracted by the Town of Westfield to conduct a pavement condition assessment and analysis update on approximately 100 centerline miles of Town maintained asphalt roadways.

IMS mobilized their Laser Road Surface Tester (RST) to conduct an objective assessment using industry standard pavement distress protocols such as those found in ASTM D6433-11. Following the Utility improvements, the Town's network average Pavement Condition Index was found to be a 66 and the Town's backlog (roads below a PCI of 40) was at 7%. *See section 4 for more information*

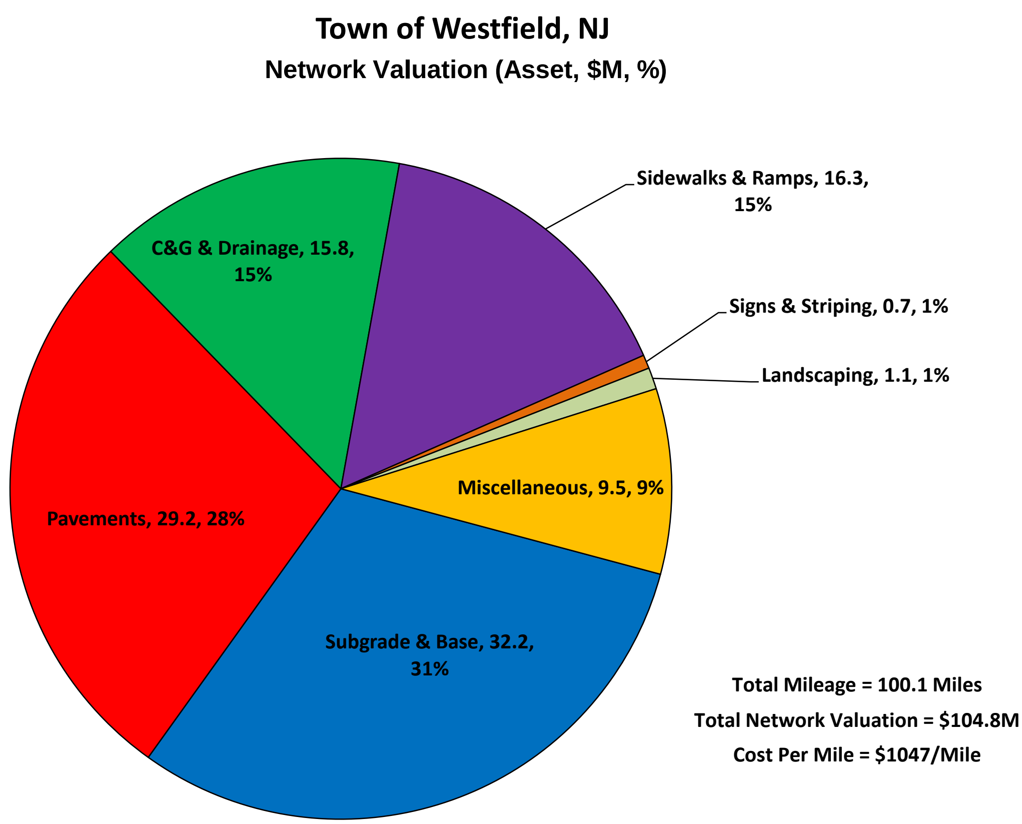


Figure 1- Replacement Value of Roadway Network

As seen in **Figure 1**, Westfield has just over 100 centerline miles of roadway, encompassing nearly 2M square yards of pavement surfacing. At an average replacement cost for a typical roadway just over $1M per mile, not including the value of the land, the Town has over $104.8M invested in its paved roadway network.

Summary Metrics of Health

Pavement Condition Index (PCI) – The PCI score is a ranking assessment on the overall health of a pavement segment on a scale of 0 to 100. The network average PCI is a good global indicator of a network's overall health. *(Explained in section 4)*

Percent of Excellent Roads – Roads with a condition category of Excellent are those that score between a PCI of 85 to 100.

Backlog – Backlog is the Very Poor and Poor roads (between a PCI of 0 and 40) that represent a portion of the network in need of extensive rehabilitation such as full and partial reconstruction. Using sound pavement management and finance principles, a very healthy network will have a backlog of 10% or less.

Westfield met three out of three of the metrics for evaluating the quality of its roadway network.

- ✓ Westfield's network average pavement condition score is slightly above the national average currently seen by IMS of 60 to 65, with the Town's average scoring a 66.
- ✓ The number of streets rated Excellent is above the minimum recommended target of 15% at 20.8%
- ✓ The backlog amount is below the average value of 12% at 6.9%.

Budget Scenarios

See section 5 for more information

The current annual budget for Westfield is $1.8M per year dedicated to pavement preservation and rehabilitation. This will increase the backlog to 12% while elevating the average PCI to a 70 over 5 years. Please note this number is an annual budget average across all 5 years of the analysis horizon.

The Recommended Budget is $3.52M per year and will elevate the network average PCI to a 74 while increasing the backlog to 10%.

Executive Summary Conclusion

The Westfield network has an average PCI of 66 and a backlog of 6.9%, with most of the network landing in the Very Good to Excellent PCI range. With the Town's existing budget, the network conditions will continue to improve into the 70s PCI range and backlog will increase to 12%. It is worth noting that the Town does have a fair amount of streets approaching the end of their lifespan where overlays can be effective, representing a percentage of the network at the steepest part of their deterioration curves.

2.0 PRINCIPLES OF PAVEMENT MANAGEMENT

2.1 PAVEMENT PRESERVATION

Preservation of existing roads and street systems has become a major activity for all levels of government. Because municipalities must consistently optimize the spending of their budgets, funds that have been designated for pavement must be used as effectively as possible. The best method to obtain the maximum value of available funds is through the use of a pavement management system.

Pavement management is the process of planning, budgeting, designing, evaluating, and rehabilitating a pavement network to provide maximum benefit with available funds.

A pavement management system is a set of tools or methods that assist decision makers in finding optimal strategies for providing and maintaining pavements in a serviceable condition over a given time period. The intent is to identify the optimum level of long-term funding to sustain the network at a predetermined level of service while incorporating local conditions and constraints.

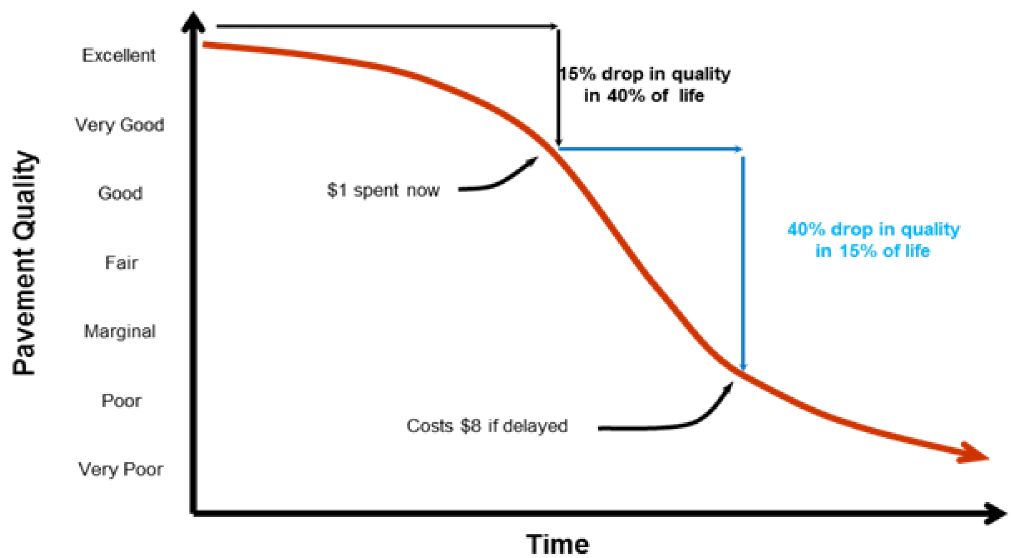


Figure 2 – Pavement Deterioration and Life Cycle Costs

As shown as **Figure 2**, the streets that are repaired while in good condition will cost less over their lifetime than those left to deteriorate to a poor condition. Without an adequate routine pavement maintenance program, streets require more frequent reconstruction, thereby costing millions of extra dollars.

The key to a successful pavement management program is to develop a reasonably accurate performance model of the roadway, and then identify the optimal timing and rehabilitation strategy. The resultant benefit of this exercise is realized by the long term cost savings and increase in pavement quality over time. As illustrated in **Figure 2,** pavements typically deteriorate rapidly once they hit a specific threshold. A $1 investment after 40% lifespan is much more effective than deferring maintenance until heavier overlays or possibly reconstruction are required just a few years later.

Once implemented, an effective pavement information management system can assist agencies in developing long-term rehabilitation programs and budgets. The key is to develop policies and practices that delay the inevitable total reconstruction for as long as practical yet still remain within the target zone for cost effective rehabilitation. That is, as each roadway approaches the steepest part of its deterioration curve, apply a remedy that extends the pavement life, at a minimum cost, thereby avoiding costly heavy overlays and reconstruction. **Figure 3** illustrates the concept of extending pavement life through the application of timely rehabilitations.

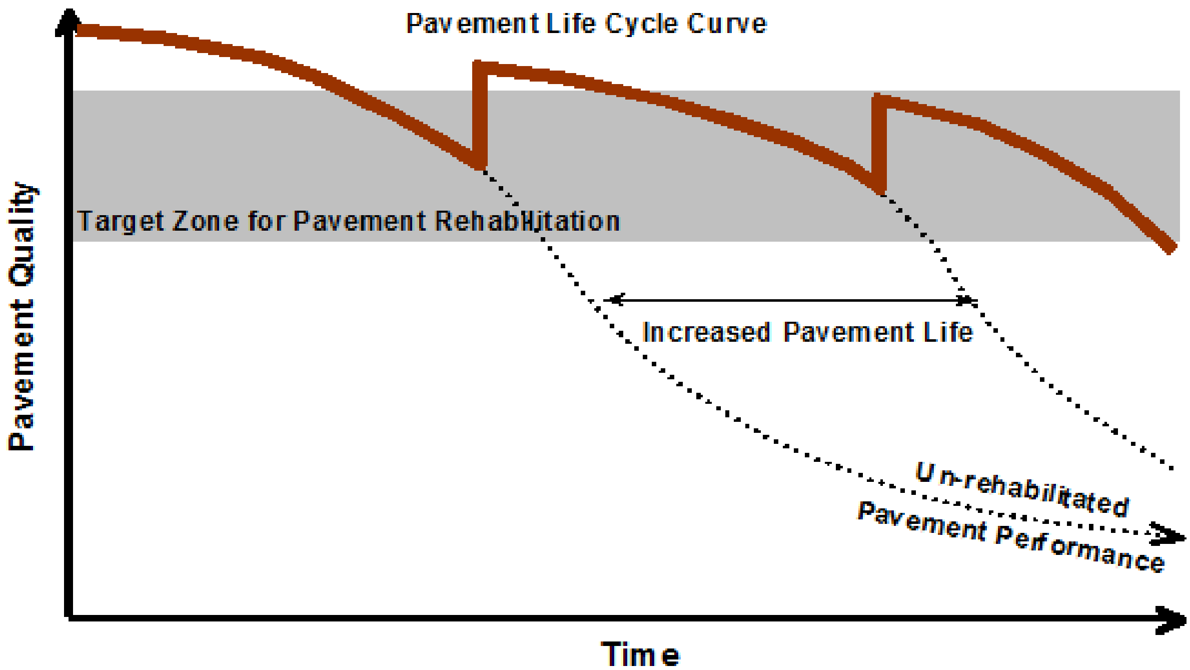


Figure 3 – Pavement Life Cycle Curve

Ideally, the lower limit of the target zone shown in **Figure 3** would have a minimum PCI value in the 60 to 70 range to keep as many streets as possible requiring a thin overlay or less. The upper limit would tend to fall close to the higher end of the Very Good category – that is a pavement condition score approaching 85. Other functions of a pavement management system include assessing the effectiveness of maintenance activities, new technologies, and storing historical data and images.

For Westfield, a prioritization methodology based on pavement condition, pavement materials, functional class, and strength rating was used to analyze the network condition and develop the proposed 5 year rehabilitation plan.

The analysis methodologies and data collection technologies were based on *ASTM D6433 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys* (hereinafter ASTM D6433) for assessment of pavement surface condition and the International Roughness Index (IRI) for quantification of pavement roughness on all Town streets. These measurements of pavement quality are combined to form an overall 0 to 100 Pavement Condition Index (PCI), with 100 being the best.

2.2 ECONOMIC IMPACTS OF MAINTENANCE & REHABILITATION

The role of the street network as a factor in the Town's well-being cannot be overstated. In the simplest of terms, roadways form the economic backbone of a community. They provide the means for goods to be exchanged, commerce to flourish, and commercial enterprises to generate revenue. As such, they are an investment to be maintained.

The overall condition of an agency's infrastructure and transportation network is a key indicator of economic prosperity. Roadway networks, in general, are one of the most important and dynamic sectors in the global economy. They have a strong influence on not only the economic well-being of a community, but a strong impact on quality of life. Well-maintained road networks experience multiple socioeconomic benefits through greater labor market opportunities and decreasing income gap.

As a crucial link between producers and their markets, quality road networks ensure straightforward access to goods and drive global and local economies. Likewise, higher network quality has a strong correlation to improvements in household consumption and income. Roads also act as a key element to social cohesion by acting as a median for integration of bordering regions. This social integration promotes a decreased gap in income along with diversity and a greater sense of community that can play a large role in decreasing rates of poverty.

Conversely, deterioration of roads can have adverse effects on a community and may bring about important and unanticipated welfare effects that the governments should be aware of when cutting transportation budgets. Poor road conditions increase fuel and tire consumption while shortening intervals between vehicle repair and maintenance. In turn, these roads result in delayed or more expensive deliveries for businesses and consumers. Economic effects of poor road networks, such as time consuming and costly rehabilitation, can be reduced if a proactive maintenance approach is successfully implemented. To accomplish this, a pavement assessment and analysis should be completed every few years in an effort update the budget models and rehabilitation plans. As shown below, the IMS Laser Road Surface Tester (featured in **Figure 4**) was mobilized to Westfield to conduct an objective survey.

Figure 4 – Laser Road Surface Tester (RST)

3.0 THE PAVEMENT MANAGEMENT PROCESS

3.1 FUNCTIONAL CLASS REVIEW

As part of the scope of this assignment, the functional classification designations currently used in the Westfield pavement management program were adopted for their use in the pavement analysis.

Although there is no uniform standard for classifying pavement into functional classes, The Federal Highway Administration (FHWA), American Public Works Association (APWA) and Institute of Transportation Engineers (ITE) offer some broad guidelines on how to assign classifications that were followed in this study.

The Town's functional classification definitions used in the assessment are as follows:

1. **Town Arterial (ART)** – all cross Town corridors consisting of 2 to 4 or more lanes, generally spaced at 1 mile intervals with daily traffic counts generally exceeding 10,000 vehicles per day. Major cross Town corridors with a landscaped median were also assigned to Principal Arterials.
2. **Town Collector (COL)** – Continuous and discontinuous cross Town and inter-district corridors that are 2 to 4 lanes across and generally have a centerline stripe or a designated bus route. The ADT generally falls in the 1,000 to 10,000 vehicle per day range. They are typically spaced on the ½ or ¼ mile section line and on occasion, may have a short non-landscaped median. Major collectors are also assigned to streets segments leading to, or adjacent to, a major traffic generator site such as a regional shopping complex. Collectors form the entrance to communities and may have a decorative landscaped median of short duration.
3. **Minor Street** – These are the majority of the street segments consisting of all local residential roads not defined above or as industrial/commercial.

Alleys and bicycle paths were not included in this study even though they are part of the overall transportation network. The implication of this is that the final pavement management program and budget developed under this program will not cover upkeep of alleys and bicycle paths. Also, non-Town owned streets were not surveyed as they are not maintained by the Town.

The paved roadway network consists of 3 functional classes, covering approximately 100 miles of pavement. The average pavement condition index (PCI) of the roadway network is a 66 and the network's primary pavement type is asphalt. The following table and **Figure 5** summarize the functional classification splits within the system.

Town of Westfield, NJ
Network Summary by Functional Class

	Pavetype	Network	Town Arterial	Town Collector	Minor Street
Segment (Block) Count	All Streets	1123	30	200	893
	Asphalt	1122	30	200	892
	Concrete	1	0	0	1
Network Length (ft):	All Streets	528,288	11,186	88,769	428,333
	Asphalt	527,776	11,186	88,769	427,821
	Concrete	512	0	0	512
Network Length (mi):	All Streets	100.1	2.1	16.8	81.1
	Asphalt	100.0	2.1	16.8	81.0
	Concrete	0.1	0.0	0.0	0.1
Average Width (ft):	All Streets	33.3	35.1	34.4	33.1
	Asphalt	33.3	35.1	34.4	33.1
	Concrete	27.3	0.0	0.0	27.3
Network Area (yd2):	All Streets	1,956,300	43,687	339,248	1,573,365
	Asphalt	1,954,747	43,687	339,248	1,571,812
	Concrete	1,553	0	0	1,553
Current Pavement Condition	All Streets	66	80	64	66
Index (CPCI)	Asphalt	66	80	64	66
6/3/19	Concrete	93	0	0	93
Pavement Condition Index	All Streets	57	54	59	57
(Surveyed PCI)	Asphalt	57	54	59	57
	Concrete	93	0	0	93
Current Backlog (%)	All Streets	7			
Current Network Index	All Streets	61			
Surface Distress Index (SDI)	All Streets	63	79	60	63
6/3/19	Asphalt	63	79	60	63
	Concrete	91	0	0	91
Roughness Index (RI)	All Streets	73	82	72	73
6/3/19	Asphalt	73	82	72	73
	Concrete	96	0	0	96

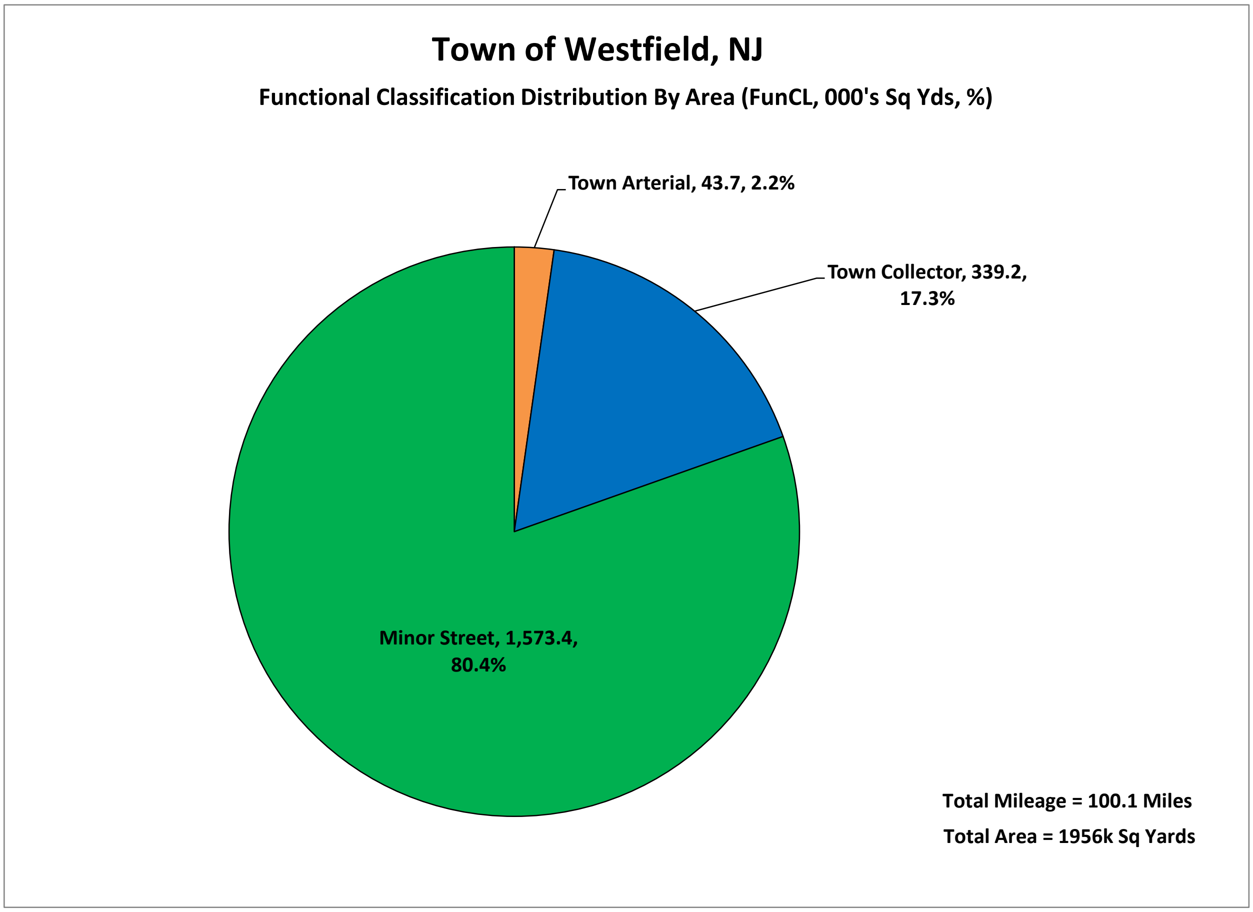


Figure 5 – Functional Class Distribution by Mileage

As discussed later in this report, the functional classifications also play a critical role in the rehabilitation candidate selection process as Arterials and Collectors are generally given preference over other rehab candidates due to their higher traffic counts and steeper deterioration curves.

The following figure (**Figure 6**) highlights the functional classifications used for the Westfield roadway network. An electronic version of this map is appended to this report.

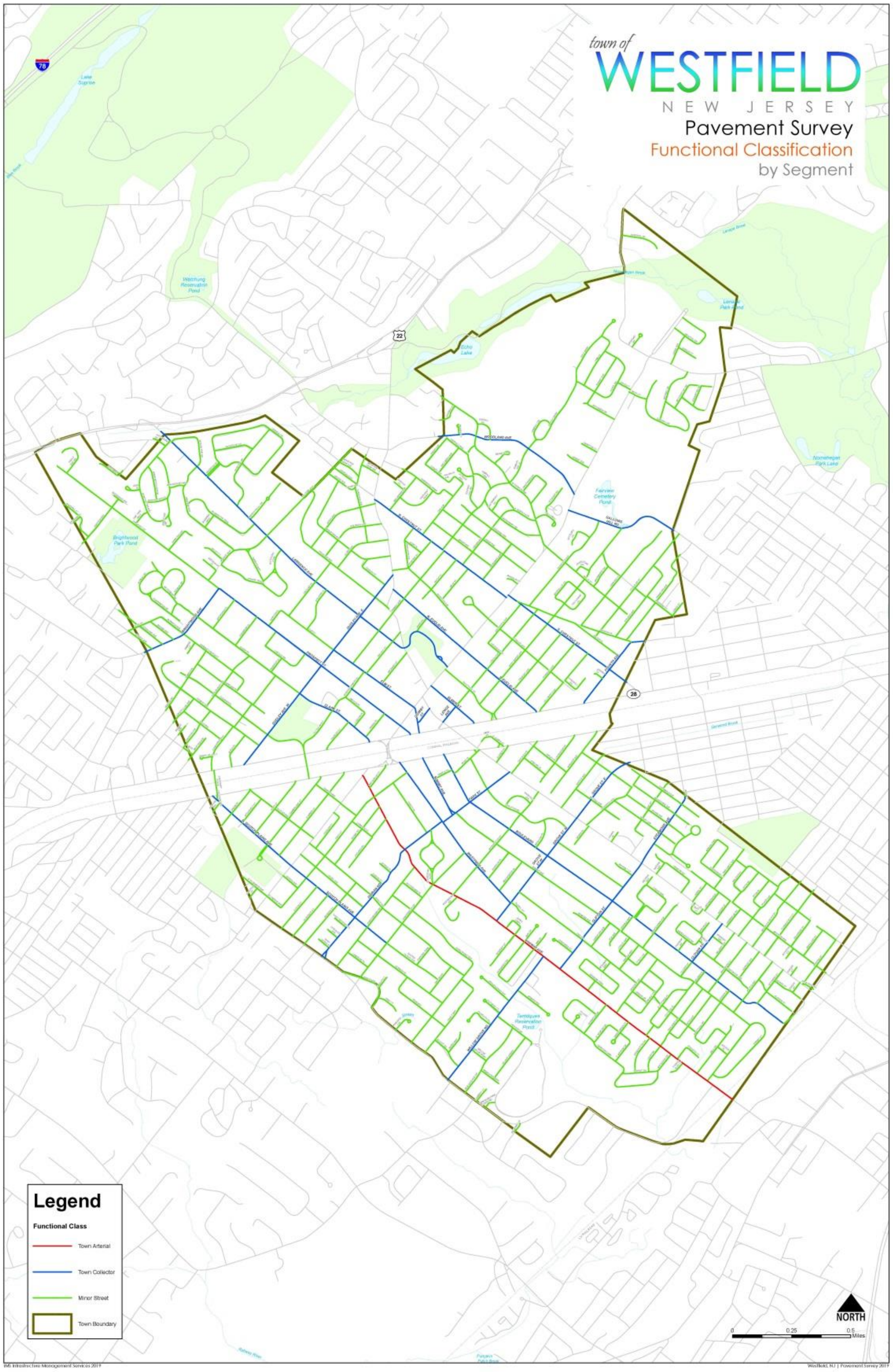


Figure 6 – Westfield Functional Classification Designation

3.2 FIELD SURVEY METHODOLOGY

Following a set of predefined assessment protocols matching the pavement management software (ASTM D6433), a specialized piece of survey equipment – referred to as a Laser Road Surface Tester (Laser RST, pictured on page 5) – is used to collect observations on the condition of the pavement surface, as well as collect high definition digital imagery and spatial coordinate information. The Laser RST surveys each local street from end to end in a single pass, while all other roadway classifications are completed in two passes.

Key pavement condition data elements collected by the Laser RST include:

Surface Distress Index – The Laser RST collects surface distress observations based on the extent and severity of distresses encountered along the length of the roadway following ASTM D6433 protocols for asphalt and concrete pavements. The surface distress condition (cracking, potholes, raveling, and the like) is considered by the traveling public to be the most important aspect in assessing the overall pavement condition.

Presented on a 0 to 100 scale, the Surface Distress Index (SDI) is an aggregation of the observed pavement defects. Within the SDI, not all distresses are weighted equally. Certain load associated distresses (caused by traffic loading), such as rutting or alligator cracking on asphalt streets, or divided slab on concrete streets, have a much higher impact on the surface distress index than non-load associated distresses such as raveling or patching. Even at low extents and moderate severity – less than 10% of the total area – load associated distresses can drop the SDI considerably. ASTM D6433 also has algorithms within it to correct for multiple or overlapping distresses within a segment.

For this project, extent and severity observations were collected, processed, and loaded into the pavement management software. Within the software, the following distresses, listed in order from greatest to lowest impact, are presented as a 0 to 10 rating for review and reporting:

- Alligator Cracking – Alligator cracking is quantified by the severity of the failure and number of square feet. Even at low extents, this can have a large impact on the condition score as this distress represents a failure of the underlying base materials.
- Wheel Path Rutting – Starting at a minimum depth of ¼ inch, wheel path ruts are quantified by their depth and the number of square feet encountered. Like alligator cracking, low densities of rutting can have a large impact on the final condition score.
- Longitudinal, Transverse, Block (Map), and Edge Cracks – These are quantified by their length and width. Longitudinal cracks that intertwine are the start of alligator cracking.
- Patching – Patching is quantified by the extent and quality of patches. When the majority of a roadway surface is covered by a patch, such as a large utility replacement, the rating of the patch is minimized. All potholes are rated as patches.
- Distortions – All uneven pavement surfaces, such as depressions, bumps, sags, swells, heaves, and corrugations, are included as distortions and are quantified by the severity and extent of the affected area.
- Raveling – Raveling is the loss of fine aggregate materials on the pavement surface and is measured by the severity and number of square feet affected.

- Bleeding – Bleeding is the presence of free asphalt on the roadway surface caused by too much asphalt in the pavement or insufficient voids in the matrix. The result is a pavement surface with low skid resistance and is measured by the amount and severity of the area.
- Similar distresses were collected for concrete streets including divided slab, corner breaks, joint spalling, faulting, polished aggregate, and scaling.

Roughness Index – Roughness is recorded following the industry standard "International Roughness Index" (IRI), a measure of the change in elevation over a distance expressed as a slope and reported in millimeters/meter. The IRI value is converted to a 0 to 100 score and reported as the Roughness Index (RI) as follows:

$$\textbf{RI} = (11 - 3.5 \times \ln(\mathrm{IRI})) \times 10$$

ln(IRI) is the natural logarithm of IRI.

Structural Index – The network of streets was not tested for structural adequacy, instead, the relationship between the final pavement condition score and amount of load associated distresses was analyzed and each pavement section assigned a Weak, Moderate or Strong strength rating. The assigned structural index (30, 60 or 80 for weak, moderate and strong respectively) was not used in determining the overall pavement condition score, but simply to classify the pavement strength and aid in selecting appropriate rehabilitation strategies.

Pavement Condition Index (PCI) – Following our field surveys, the condition data is assembled to create a single score representing the overall condition of the pavement. The Pavement Condition Index (PCI) is calculated as follows:

PCI = 33% Roughness Index + 67% Surface Distress Index

Development of the pavement management plan and budgets were completed using Westfield - specific rehabilitation strategies, unit rates, priorities, and pavement performance curves. The process was iterative in its attempt to obtain the greatest efficiency and cost benefit.

4.0 WESTFIELD SURVEY PAVEMENT CONDITION

4.1 UNDERSTANDING THE PAVEMENT CONDITION INDEX

The following figure compares the Pavement Condition Index (PCI) to commonly used descriptive terms. Divisions between the terms are not fixed, but are meant to reflect common perceptions of condition.

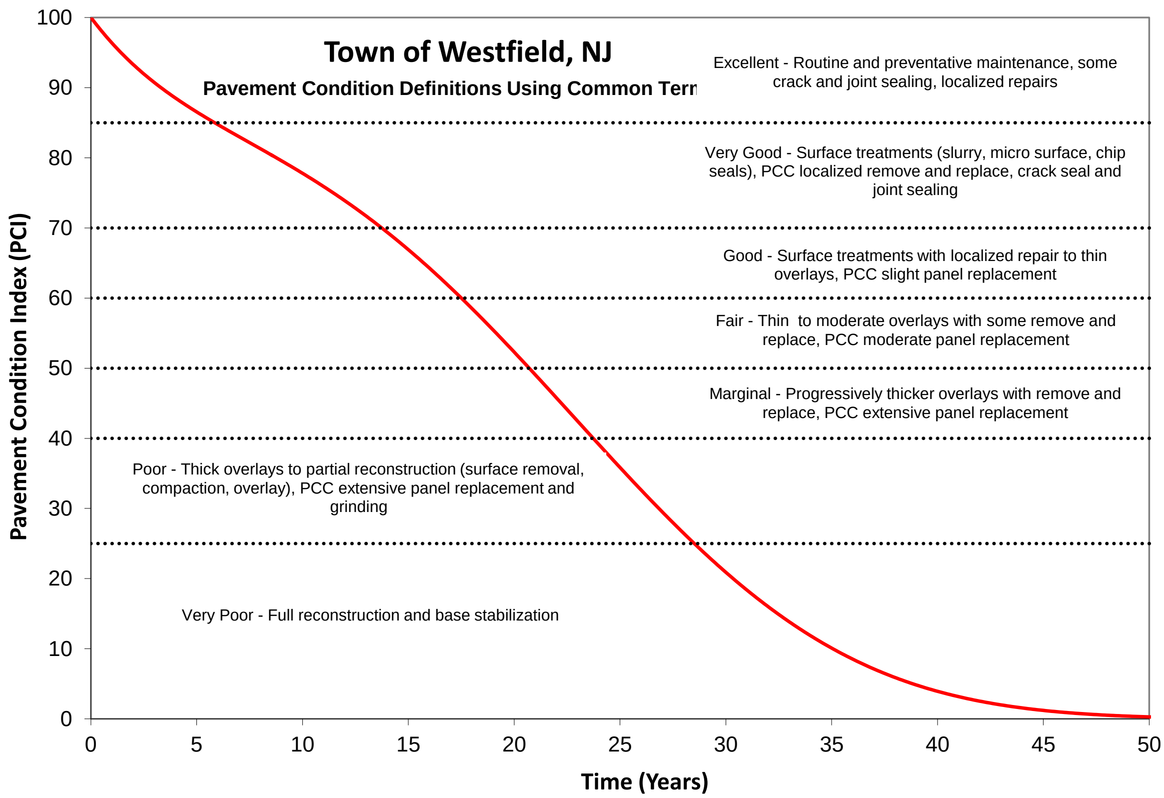


Figure 7 – Understanding the Pavement Condition Index (PCI) Score

The following table details a general description for each of these condition levels with respect to remaining life and typical rehabilitation actions:

PCI Range	Description	Relative Remaining Life	Definition
85 – 100	Excellent	15 to 25 Years	Like new condition – little to no maintenance required when new; routine maintenance such as crack and joint sealing.
70 – 85	Very Good	12 to 20 Years	Routine maintenance such as patching and crack sealing with surface treatments such as seal coats or slurries.
60 – 70	Good	10 to 15 Years	Heavier surface treatments, chip seals and thin overlays. Localized panel replacements for concrete.
40 – 60	Marginal to Fair	7 to 12 Years	Heavy surface-based inlays or overlays with localized repairs. Moderate to extensive panel replacements.
25 – 40	Poor	5 to 10 Years	Sections will require very thick overlays, surface replacement, base reconstruction, and possible subgrade stabilization.
0 – 25	Very Poor	0 to 5 Years	High percentage of full reconstruction.

4.2 WESTFIELD NETWORK CONDITION IMAGERY

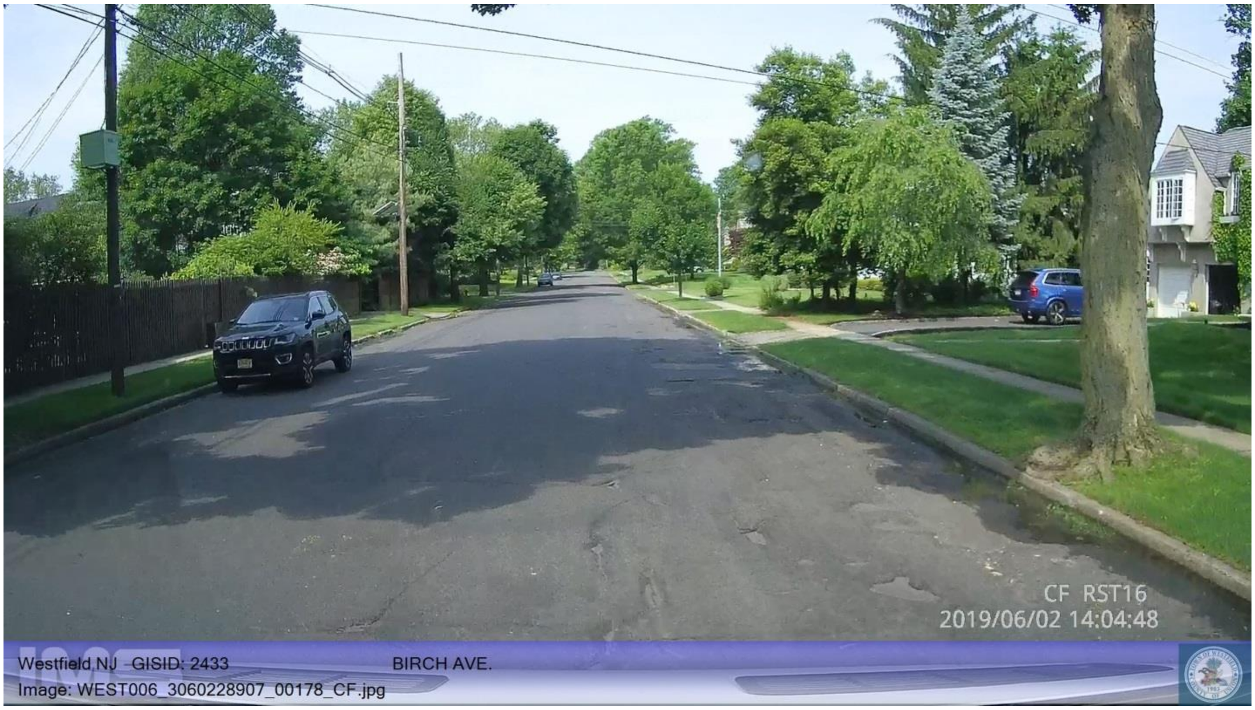
The images presented below provide a sampling of the Westfield streets that fall into the various condition categories with a discussion of potential rehabilitation strategies.

Very Poor (PCI = 0 to 25) – Complete Reconstruction

Carol Drive from Golf Edge to Lynn Lane (GISID 2675, PCI = 23) – Rated as Very Poor, this street displays spreading base failure as evidenced by the severe alligator cracking, patching and potholes. A mill and overlay on this street would not be suitable as the base has failed and would not meet an extended service life of at least 15 years. This street requires a full reconstruction and should be carefully monitored.

Deferral of reconstruction of streets rated as Very Poor will not cause a substantial decrease in pavement quality as the streets have passed the opportunity for overlay-based strategies. Due to the high cost of reconstruction, Very Poor streets are often deferred until full funding is available in favor of completing more streets that can be rehabilitated at lower costs, resulting in a greater net benefit to the Town. This strategy however must be sensitive to citizen complaints forcing the street to be selected earlier. It is important to consistently monitor these streets and check for potholes or other structural deficiencies until the street is eventually rebuilt.

Poor (PCI = 25 to 40) – Last Opportunity for Surface Base Rehabilitation



Birch Avenue from Standish Avenue to Mountain Avenue (GISID 2433, PCI = 34) – Rated as Poor, this segment still has some remaining life before it becomes a critical reconstruction need. As evident in the imagery, the existence of multiple potholes on this segment severely impacts the PCI score of the entire segment. On this street, the base is showing signs of failure in areas exhibiting severe raveling. The severely cracked areas are isolated and do not persist throughout the entire segment length and cross section. These areas should be dug out and structurally patched to attain the maximum life from any potential rehabilitation efforts. If left untreated, within a short period of time, a full reconstruction would be required.

On arterial roadways, Poor streets often require partial to full reconstruction – that is removal of the pavement surface and base down to the subgrade and rebuilding from there. On local roadways, they require removal of the pavement surface through grinding or excavation, base repairs, restoration of the curb line and drainage, and then placement of a new surface.

In general, the service life of Poor streets is such that if deferred for too long, it would require a more costly reconstruction. Streets rated as Poor are typically selected first for rehabilitation as they provide the greatest cost/benefit to the Town – that is the greatest increase in life per rehabilitation dollar spent.

Marginal (PCI = 40 to 50) – Progressively Thicker Overlays

Ayliffe Avenue from Summit Avenue to Boulevard (GISID 1159, PCI = 43) – Rated as marginal with a PCI score at the lower range between Marginal and Poor streets. Marginal streets have distresses that tend to be localized and moderate in nature – that is they do not extend the full length of the segment and can be readily dug out and repaired. This street segment highlights this characteristic as the failed area does not quite extend the full length or width of the roadway and is still serviceable. However, it also highlights the relationship between base and pavement quality. Placing an overlay on this street without repairing the base would not achieve a full 15 year life as the failure would continue to occur over time. Structural patching of the failed areas along localized rehabs would permit a full width grind and inlay on this street segment and return it to full service. The curb lines are straight and drainage is functioning well.

Marginal streets that display high amounts of load associated distresses are selected as a priority for rehabilitation as they provide the greatest cost/benefit to the Town. If left untreated, Marginal streets with high amounts of load associated distresses would deteriorate to become partial reconstruction candidates. Marginal streets that are failing due to materials issues or non-load associated failures may become suitable candidates for thick overlays if deferred, without a significant cost increase.

Fair (PCI = 50 to 60) – Thin to Moderate Overlays

North Chestnut Street from Saunders Avenue to East Broad Street (GISID 2232, PCI = 52) – Rated in the Fair category, these streets require thin to moderate overlays for asphalt when they enter their need year (generally within 2-3 points of the lower PCI in the defined range). Several distresses are present, but tend to be more localized and moderate in severity, and non-load related (primarily longitudinal and transverse cracking and raveling).

Arterial and Collector streets maintain a higher priority in the Fair category for Westfield. Local asphalt streets rated as Fair tend to receive a lower priority when developing a rehabilitation program. The reason for this is the cost to complete an overlay now would be on the order of $14.00 to $17.00/yd2. If deferred, the rehabilitation cost would only increase by about $3 to $5/yd2, again depending on the functional classification, in about 5 to 10 years. This delay represents a 20% difference over the time stated. Thus, the cost of deferral is low when compared to deferring a thick overlay to a reconstruction with a two to threefold increase in cost.

Good (PCI = 60 to 70) – Surface Treatments to Thin Overlays

Colonial Avenue from Standish Avenue to Mountain Avenue (GISID 2328, PCI = 61) – Rated as Good with the primary cause of deterioration longitudinal cracking. It also displays small amounts of load associated distresses that can easily be removed to restore the visual appearance of the roadway. The existing cracks should be sealed and the pavement surface restored, with a heavier surface treatment such as microsurfacing or double slurry to fully waterproof the pavement and cover the crack sealant. The occasional dig out and replacement may be required to correct localized deficiencies. Alternatively, depending on the extent of the distressed areas, base strength and drainage, a thin overlay may be applied.

Asphalt streets rated as Good are ideal candidates for thinner surface-based rehabilitations and local repairs. Depending on the amount of localized failures, a thin edge mill and overlay, or possibly a surface treatment, would be a suitable rehabilitation strategy for streets rated as Good. Streets that fall in the high 60 - low 70 PCI range provide the greatest opportunity for extending pavement life at the lowest possible cost, thus applying the principles of the perpetual life cycle approach to pavement maintenance. The adjacent photo is a great example of a street segment (not a Westfield Road) that displayed low load associated distresses and thus, high structural characteristics, and once the distressed areas were replaced, a slurry seal was applied. The patching accounted for less than 5 to 10% of the total area and resulted in a good looking, watertight final surface at a much lower cost than an overlay with less disruption to the neighborhood and curb line. The patches were paver laid and roller compacted.

Very Good (PCI = 70 to 85) – Surface Treatments and Localized Rehabilitation

Fourth Avenue from Salter Place to Benson Place (GISID 2024, PCI = 70) – Rated as Very Good, this road displays minor amounts of transverse cracking and patching. The surface is non-weathered, and the base is still strong. This street is an example of a candidate for preventative maintenance and light weight surface treatments to extend the life of a roadway.

Asphalt streets rated as Very Good generally need lightweight surface-based treatments such as surface seals, slurries, chip seals or microsurfacing. Routine maintenance such as crack sealing and localized repairs often precede surface treatments. The concept is to keep the cracks as waterproof as possible through crack sealing and the application of a surface treatment. By keeping water out of the base layers, the pavement life is extended without the need for thicker rehabilitations such as overlays or reconstruction. Surface treatments also tend to increase surface friction and visual appearance of the pavement surface but do not add structure or increase smoothness.

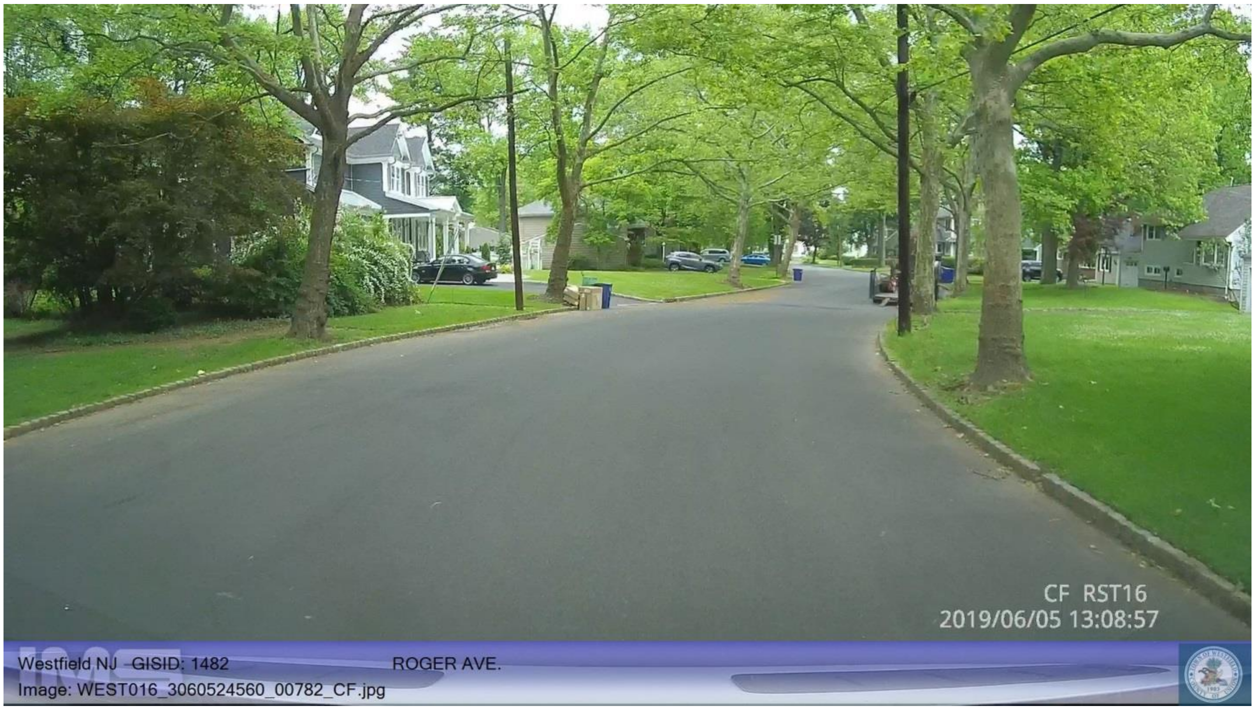
Surface treatments may include:

- *Double or single application of slurry seals (slurries are a sand and asphalt cement mix).*
- *Microsurfacing – asphalt cement and up to 3/8 sand aggregate.*
- *Chip seals and cape seals (Chip seal followed by a slurry).*

Additional cost benefits of early intervention include:

- *Less use of non-renewable resources through thinner rehabilitation strategies.*
- *Less intrusive rehabilitation and easier to maintain access during construction.*
- *Easier to maintain existing drainage patterns.*

Excellent (PCI = 85 to 100)



Roger Avenue from Grandview Avenue to City Limit (GISID 1482, PCI = 85) – Rated as Excellent, displaying little to no surface distresses. The ride is smooth and the surface is non-weathered and the base is strong. In a couple of years, this street segment would be an ideal candidate for routine maintenance activities such as crack sealant rehabilitation.

In terms of pavement management efficiency, a program based on worst-first, that is starting at the lowest rated street and working up towards the highest, does not achieve optimal expenditure of money. Generally, under this scenario, agencies can not sufficiently fund pavement rehabilitation and lose ground despite injecting large amounts of capital into the network.

The preferred basis of rehabilitation candidate selection is to examine the cost of deferral of a street, against increased life expectancy.

4.3 EVALUATING THE PAVEMENT QUALITY AND BACKLOG

The concept of the Pavement Condition Index (PCI) score, backlog percentage and number of streets rated as Excellent must be fully understood in order to understand and develop an effective pavement management program. These three metrics should fall into certain ranges in order to measure the quality and long term viability of a network.

The PCI score indicates the overall pavement condition and represents the amount of equity in the system; it is the value most commonly considered when gauging the overall quality of a roadway network. It may also be used to define a desired level of service: that is, an agency may wish to develop a pavement management program such that in five years the overall network score meets a set minimum value. Obviously, the higher the PCI score the better off the overall network condition is. Agencies with an average PCI score above 80 (when considering surface distress, roughness and possibly strength) are rare and found only in a few select communities. Less than 1 in 20 communities surveyed by IMS have that high of a condition average. Averages between 65 and 80 are indicative of either newer networks, or ones that have an ongoing pavement rehabilitation program and tend to be fully funded. Scores between 60 and 65 are common and represent a reasonable average providing a satisfactory balance between levels of service and funding, and when taken with the other two metrics may represent a well-managed and funded network. A minimum score of 60 means that overall the network falls at the lower end of the range where light weight surface treatments and thin overlays are the standard rehabilitation practice. Below a 60 means an agency has to rely on more costly rehabilitations and reconstructions to address condition issues.

At the upper end of the condition scale, a minimum of 15% of the network should be rated as Excellent. Generally, at or above 15%, means that a noticeable percentage of the roadway network is in like new condition, requiring only routine maintenance. While higher percentages of streets rated as Excellent are certainly desirable, the annual cost to maintain rates at higher multiples is often cost prohibitive. Below 15% means the agency is struggling to effectively rehabilitate their network on an annual basis. The 15% marker represents a cost effective balance between annual investment and satisfactory level of service.

Backlog roadways are those that have dropped sufficiently in quality to the point where surface based rehabilitation efforts would no longer prove to be cost effective. These roadways are rated Poor or Very Poor and will require either partial or total reconstruction. Backlog is expressed as the percentage of roads requiring reconstruction as compared to the network totals.

It is the backlog, however, that defines the amount of legacy work an agency is facing and is willing to accept in the future. It is the combination of the three metrics that presents the true picture of the condition of a roadway network, and conversely defines improvement goals.

Generally, a backlog of 10% to 15% of the overall network is considered manageable from a funding point of view with 12% being a realistic target. Fifteen percent (15%) is used as a control limit to indicate the maximum amount of backlog that can be readily managed. Backlog rates below 10%, again are certainly desirable, but financially unachievable for a large percentage of agencies. Backlogs approaching 20% or more tend to become unmanageable, unless aggressively checked through larger rehabilitation programs, and will grow at an alarming rate. At 20% a tipping point has been met and the backlog tends to increase faster than an agency’s ability to reconstruct their streets.

4.4 WESTFIELD NETWORK CONDITION DISTRIBUTION

Figure 8 presented below shows the distribution of pavement condition for the roadway network in Westfield. The average PCI for the network is 66. While direct comparisons to other agencies are difficult due to variances in ratings systems, Westfield is slightly above average when compared to other agencies recently surveyed by IMS, which typically fall in the 60 to 65 range.

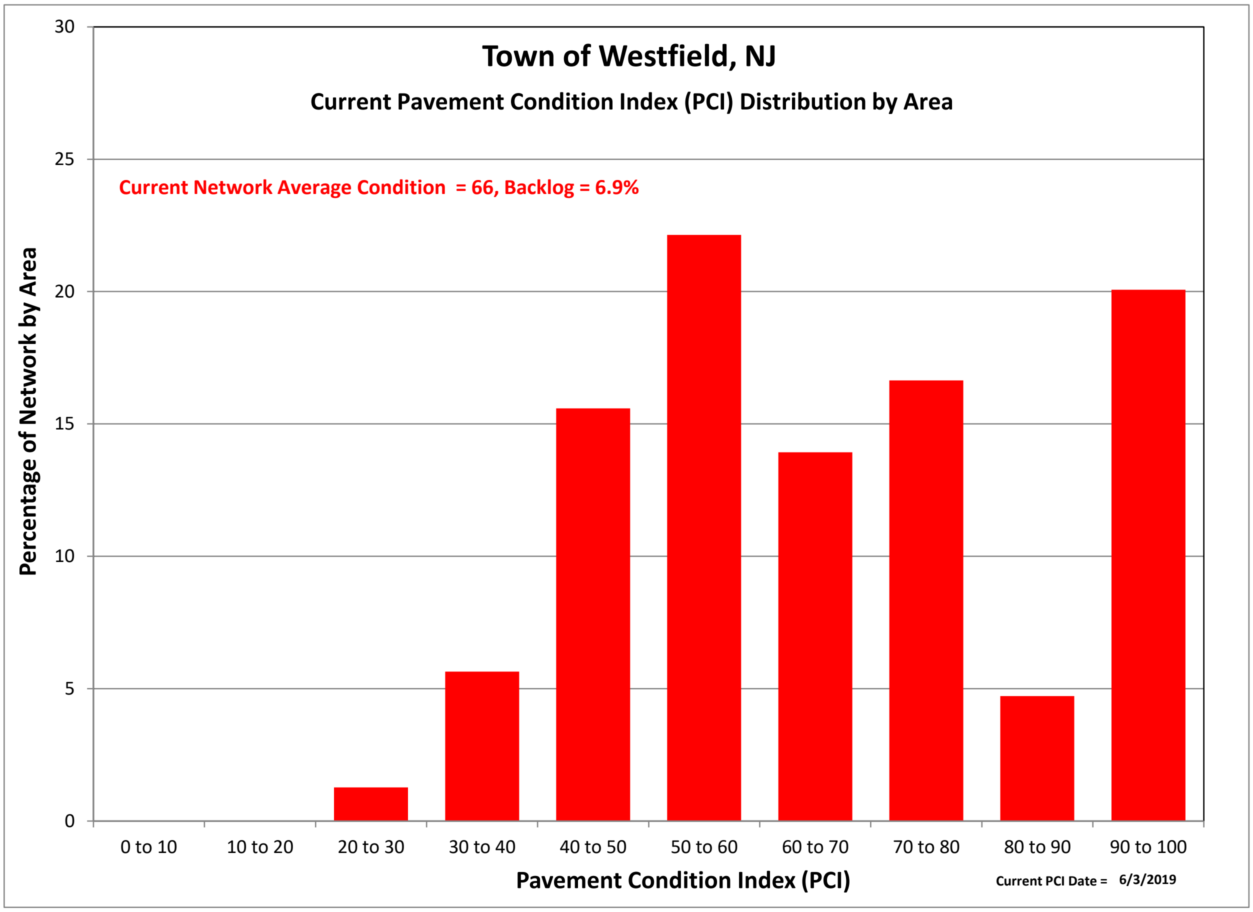


Figure 8 – Roadway Network Present Status

- This is reflective of a moderately aged network that has had some recent roadway renewal effort.
- Simultaneously, the Town has a fair sample of streets that are approaching the end of their life where surface based rehabilitations, such as overlays, can be effective.
- Traditionally we expect to see a bell curve that is skewed to the right and centered between a PCI of 60 and 70. The Westfield network curve illustrated above does not follow this norm and shows the positive impact of recent roadway renewal effort over the last several years.

The following graph **(Figure 9)** plots the same pavement condition information, but instead of using the actual Pavement Condition Index (PCI) value, descriptive terms are used to classify the roadways.

- Twenty-one percent (21%) of the network can be considered in Excellent condition and require only routine maintenance.
- Twenty-one percent (21%) of the network falls into the Very Good classification. These are roads that benefit most from preventative maintenance techniques such as microsurfacing, slurry seals and localized panel repairs.
- Fourteen percent (14%) of the streets are rated as Good and are candidates for lighter surface-based rehabilitations such as thin overlays or slight panel replacements.
- Thirty-eight percent (38%) of network can be considered Fair to Marginal condition representing candidates for progressively thicker overlay-based rehabilitation or panel replacements. If left untreated, they will decline rapidly into reconstruction candidates.
- The remaining seven percent (7%) of the network is rated as Poor or Very Poor, meaning these roadways have failed or are past their optimal due point for overlay or surface-based rehabilitation and may require progressively heavier or thicker forms of rehabilitation (such as extensive panel replacement, surface reconstruction or deep patch and paving) or total reconstruction.

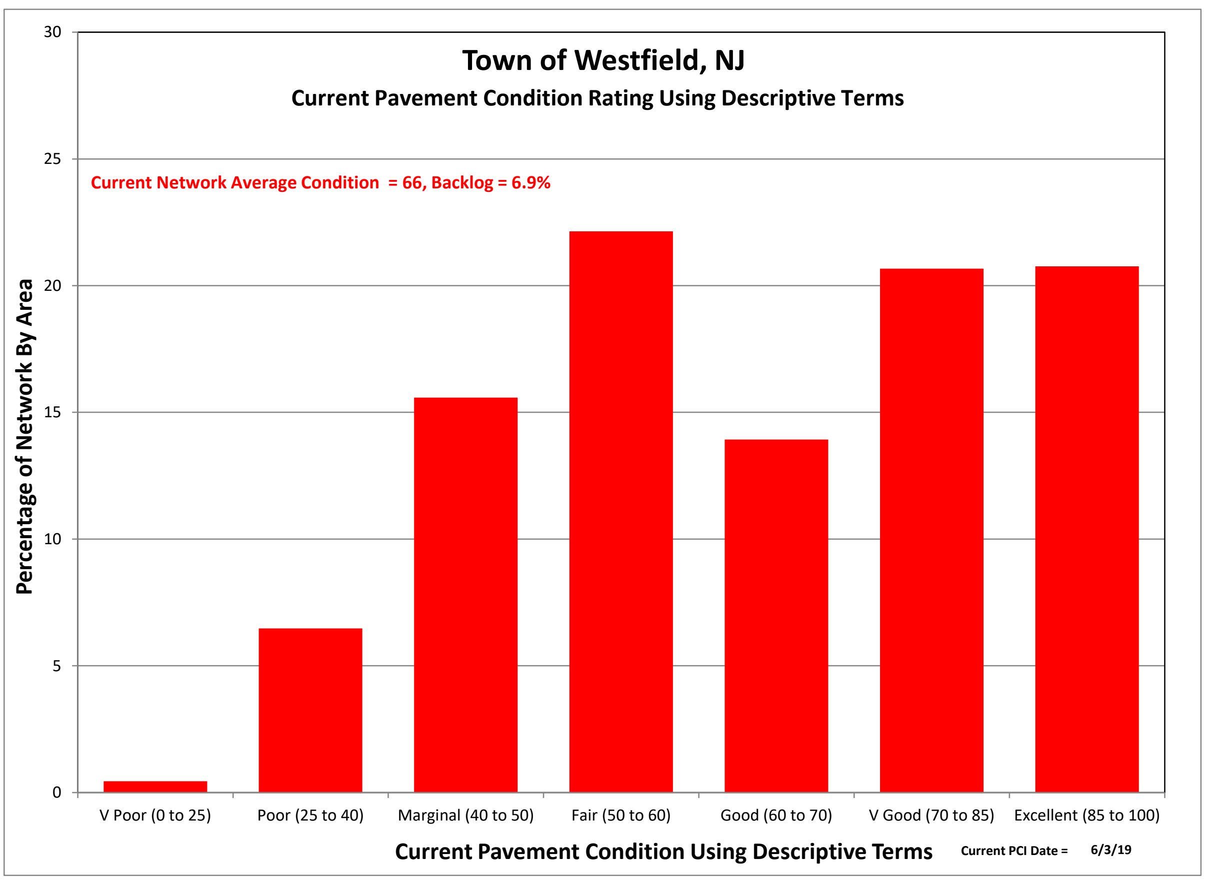


Figure 9 – Roadway Network Present Status Using Descriptive Terms

Figure 10 presents the surveyed condition of the streets using PCI (Pavement Condition Index). An electronic version of this map is appended to this report.

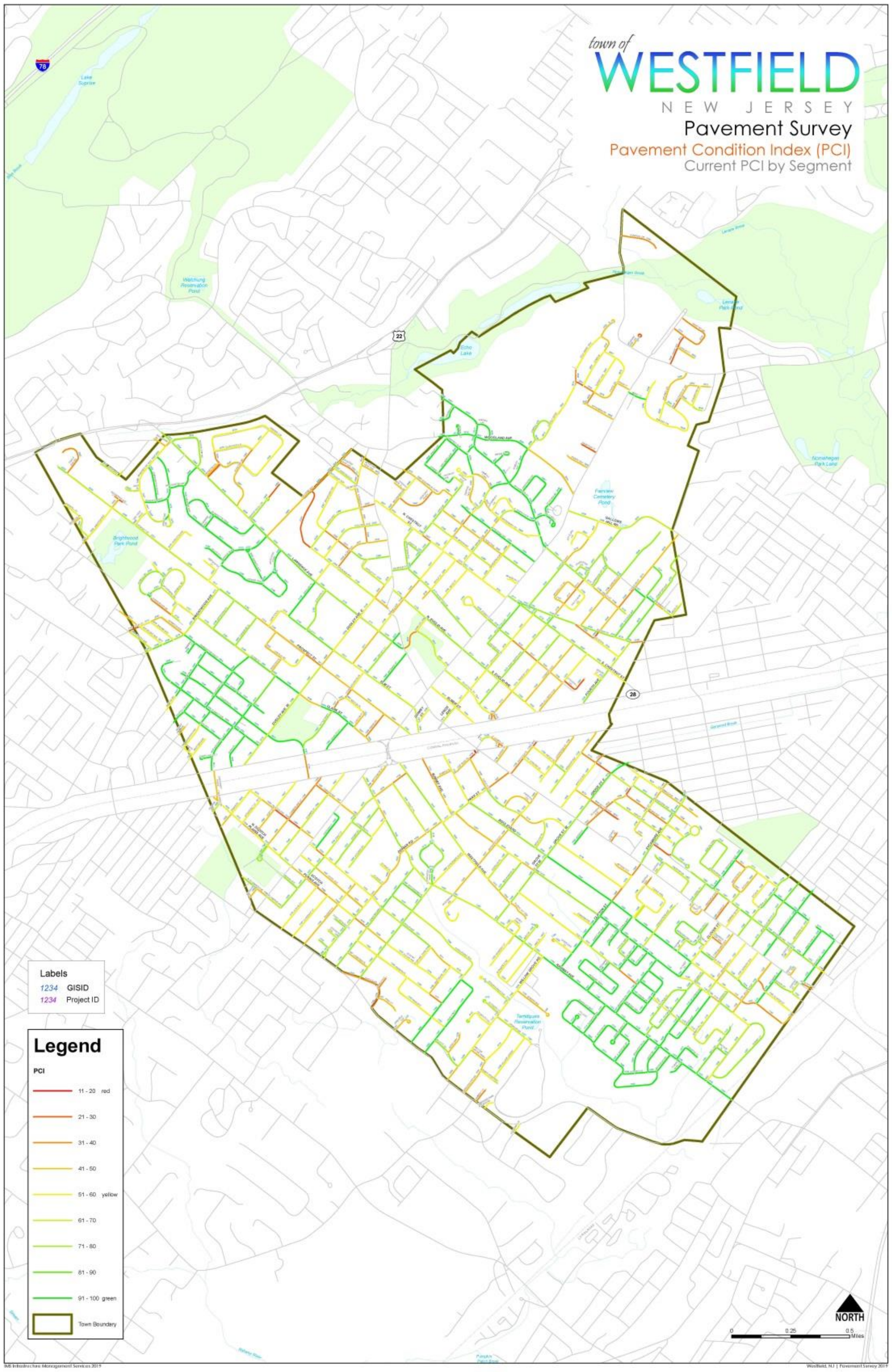


Figure 10 – Westfield by Segment Using Pavement Condition Index (PCI)

4.5 CONDITION BY FUNCTIONAL CLASSIFICATION

Figure 11 highlights the pavement condition distribution for the arterial, collector, and local streets. Keep in mind that arterial roadways, the streets that have the majority of traffic use and link various parts of the Town together, may be considered the thoroughfares of the Town and during the budget development process, should receive the highest priority when selecting rehabilitation candidates.

- The **Town arterial network** has an average PCI of **80**
- The **Town collector network** has an average PCI of **64**
- The **Minor Street network** has an average PCI of **66.**

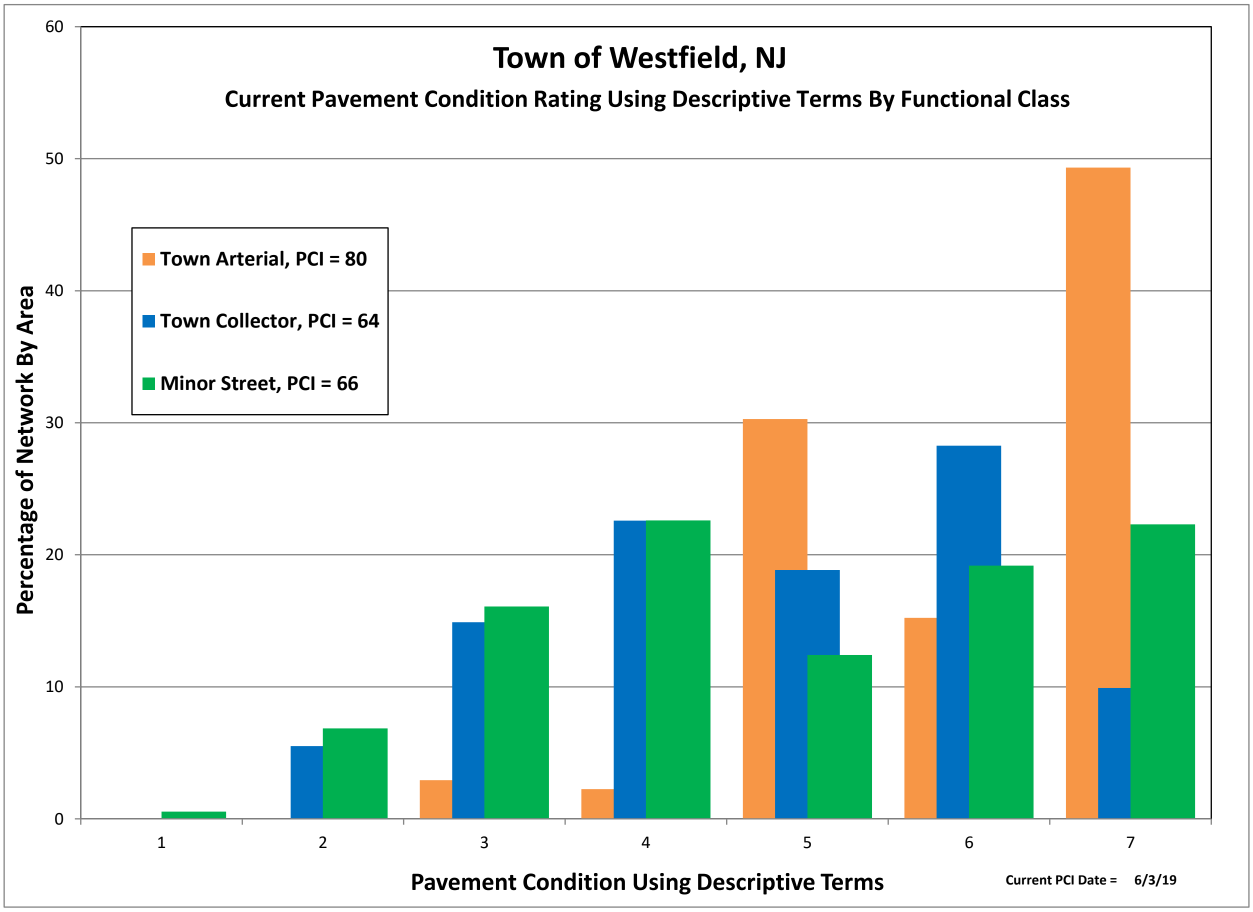


Figure 11 – Condition Rating by Functional Classification

4.6 STRUCTURAL AND LOAD ASSOCIATED DISTRESS ANALYSIS

Structural testing and analysis was not performed for the Town of Westfield. Instead, analysis of the cause of pavement failure for these street segments was completed by examining the types of distresses that have caused the PCI score to drop.

Surface distresses may be categorized into two classifications – load associated distresses (LADD) and non-load associated distresses (NLAD). Load associated distresses are those that are directly related to traffic loading and structural capacity. Non-load associated distresses are those that result from materials or environmental issues including shrinkage (transverse) cracking, bleeding and raveling. Generally, load associated distresses affect the overall condition score more than non-load associated distresses – as is the case in Westfield. For asphalt streets, roadways were classified as Weak, Moderate, or Strong.

The purpose of the structural analysis is twofold:

- The structural analysis provides input into which performance curve each segment is to use – performance curves are used to predict pavement deterioration over time.
- Structural analysis assists in rehabilitation selection by constraining inadequate pavement sections from receiving too light of a rehabilitation and conversely, identifying segments suitable for lighter weight treatment.

Figure 12 plots the relationship of the load associated distresses (shown in red) against pavement condition. As can be seen from the plot, at higher PCI scores, most pavements fall into the moderate strength classification as the distresses have not yet begun to manifest themselves into severe failures. As the PCI score drops, the load associated distresses typically affect the PCI score to a higher degree with more segments being classified as weak. Conversely, segments that have a declining PCI score and low LADD, are classified as strong as they display few load associated failures. High PCI score (above 60) rehab selections should focus on pavement preservation activities such as surface treatments or thin overlays, possibly with some localized pavement repairs and crack sealing.

The sum of the Load-Associated Distress deducts (LADD) is also used to qualify the appropriate rehabilitation strategy selection in addition to the overall pavement condition score. For example, a street that has a good PCI score (that is between 60 and 70) and is displaying relatively low load associated distress deducts would be a suitable candidate for a surface treatment in place of a thin overlay in that the PCI score is more influenced by materials issues such as transverse cracking or raveling.

Overall, the low amounts of streets exhibiting weak performance can generally be attributed to poor subgrade conditions, insufficient pavement thickness and increased traffic loading – in particular heavy, side-loading garbage and recycling trucks (an unintended consequence of green initiatives) along with school buses and delivery vehicles. The average weight of these vehicles coupled with tire pressure and configuration today compared to those from a few decades ago has increased drastically.

- The upper black diagonal line identifies segments that have a high ratio of load associated distresses compared to their PCI score. These segments are classified as weak.
- The lower black diagonal line identifies segments that have a low ratio of load associated distresses compared to their PCI score and are classified as strong.
- Segments that fall between the two lines are assigned a moderate pavement strength.

The sum of the Load-Associated Distress deducts (LADD) is also used to qualify the appropriate rehabilitation strategy selection in addition to the overall pavement condition score.

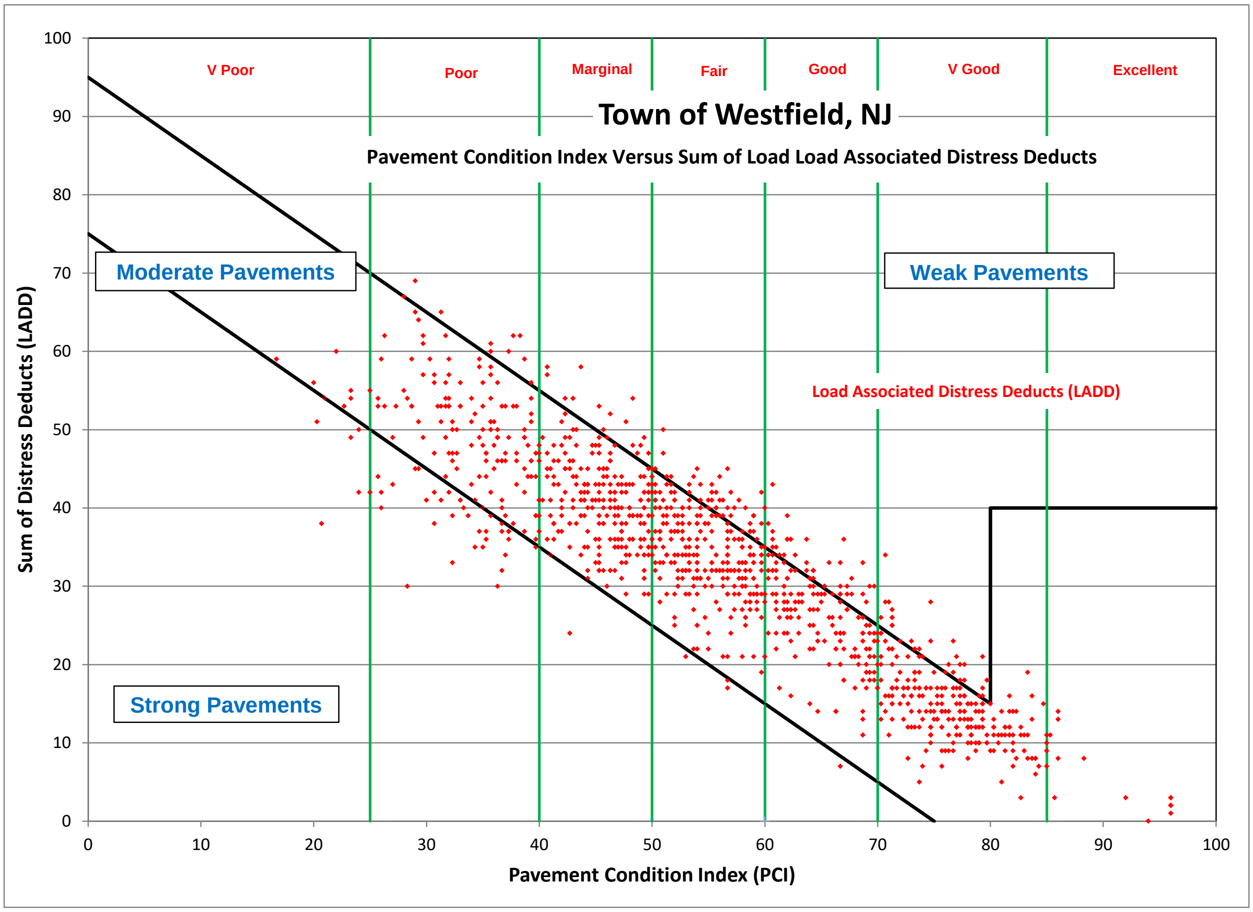


Figure 12 – Pavement Condition Index versus Sum of Distress Deducts

5.0 REHABILITATION PLAN AND BUDGET DEVELOPMENT

5.1 KEY ANALYSIS SET POINTS AND PAVEMENT PERFORMANCE CURVES

Pavement management analysis requires user inputs in order to complete its condition forecasting and prioritization. A series of operating parameters were developed in order to create an efficient program that is tailored to the Town's needs.

Some of the highlights include:

- The pavement performance curves that are used to predict future pavement condition. Asphalt streets are classified as weak, moderate, or strong, and then assigned the appropriate pavement performance curve based on their functional classification to use in the analysis. The concept of load associated distresses does not apply to concrete streets.
- The shape of performance curves reflect the concept of deferred maintenance and salvage life. Instead of dropping to an absolute PCI value of 0 after 40 years of service, the curves are designed to become asymptotic to the age axis and have a whole life of approximately 50 to 60 years depending on pavement type. This indicates the notion that once a street deteriorates past a specific threshold – about a PCI of 20, age becomes less important in rehab selection.
- Priority ranking analysis uses prioritization for rehabilitation candidate selection. It is designed to capture as many segments in their need year based on the incremental cost of deferral. The higher the functional classification of a street, the higher priority a segment is given.

Rehabilitation Strategies and Unit Rates

The rehab strategies and unit rates used in the pavement analysis can be found on the following page. Some important parameters include:

- **Rehab Code and Activity** – The assigned identifier and name to each rehabilitation strategy. The term "RR" refers to "Remove and Replace", otherwise known as Structural Patching. When this term is present, additional funds have been assigned to the strategy to allow for an increased amount of preparation work and patching. The relative terms of thin, moderate and thick are used to describe the overlay thickness. This is to facilitate consistency in the naming convention, but does not imply the same material thickness has to be used for each functional classification.

  The recommended rehab activities for any given PCI range may vary due to pavement strength and functional classification. For example, an arterial between a PCI of 50 to 60 may receive a thin to moderate overlay, while a local access road may only receive a chip seal or thin overlay.
- **Unit Rates** – The rehab costs are presented on a per square yard basis for each pavement type, functional class, and rehabilitation activity combination. The rates were developed using typical national averages for similar activities and adjusted for Westfield's location and unique conditions. An additional burden to all costs was also added to cover Town overheads, design and engineering and inspection. Costs for peripheral concrete rehab (valley gutters, inlets, approaches, etc.) have not been included in the analysis.

The unit rates are reflected in the network value, final budgets, and average cost/mile for doing work in Westfield.

Town of Westfield, NJ
Rehabilitation Strategies and Unit Rates

Pavetype	Rehab Code	Rehab Activity	Rehab Group 1 Min PCI	Critical PCI (Need Year)	Max PCI	Base Unit Rate ($/yd2)	State Arterial Unit Rate ($/yd2)	County Arterial Unit Rate ($/yd2)	Town Arterial Unit Rate ($/yd2)	Town Collector Unit Rate ($/yd2)	Minor Street Unit Rate ($/yd2)	Construction Activities Burden Included in Unit Rates (%)	Agency Overheads Included in Unit Rates (%)	Reset PCI	Steady State Life Cycle (Yrs)	CBA Rehab Priority (Info Only)
All	5	Routine Maintenance	85	100	100	0.00	0.00	0.00	0.00	0.00	0.00	0	0		1	
Asphalt	10	Slurry Seal / Seal Coat	80	82	85	3.50	3.90	3.80	3.70	3.70	3.50	25	15	85	3	15
Asphalt	20	MicroSurface	70	73	80	4.90	5.40	5.30	5.20	5.10	4.90	25	15	88	14	7
Asphalt	23	MicroSurface + Strctrl Ptch	70	73	80		6.20	6.10	6.00	5.90	5.70	25	15	88	14	8
Asphalt	26	MicroSurface + Strctrl Ptch	70	73	80		7.00	6.90	6.80	6.70	6.40	25	15	88	14	6
Asphalt	30	Edge Mill + Thin Overlay (1.5 - 2.0)	60	63	70	18.63	20.50	20.25	20.00	19.50	18.75	25	15	92	24	10
Asphalt	33	Edge Mill + Thin Overlay (1.5 - 2.0) + Strctrl Ptch	60	63	70		22.50	22.00	21.75	21.50	20.50	25	15	92	24	14
Asphalt	36	Edge Mill + Thin Overlay (1.5 - 2.0) + Strctrl Ptch	50	54	60		24.25	24.00	23.75	23.25	22.25	25	15	92	24	5
Asphalt	40	EM/FWM + Moderate Overlay (2.0 - 3.0)	50	54	60	23.63	27.25	26.75	26.25	25.50	23.75	25	15	94	30	12
Asphalt	43	EM/FWM + Moderate Overlay (2.0 - 3.0) + Strctrl Ptch	50	54	60		29.25	28.75	28.00	27.25	25.50	25	15	94	30	4
Asphalt	46	EM/FWM + Moderate Overlay (2.0 - 3.0) + Strctrl Ptch	40	44	50		31.25	30.75	30.00	29.25	27.25	25	15	94	30	9
Asphalt	50	FWM + Thick Overlay (> 2.0 - 3.0)	40	44	50	28.63	34.50	33.50	33.00	31.50	28.50	25	15	96	37	11
Asphalt	53	FWM + Thick Overlay (> 2.0 - 3.0) + Strctrl Ptch	40	44	50		37.00	36.00	35.00	34.00	30.50	25	15	96	37	13
Asphalt	56	FWM + Thick Overlay (> 2.0 - 3.0) + Strctrl Ptch	25	30	40		39.50	38.50	37.50	36.00	32.50	25	15	96	37	1
Asphalt	60	Surf Recon + Base Rehab / FWM + Strctrl Ptch + Olay	25	30	40	46.50	56.50	54.50	53.00	51.50	46.50	25	15	98	45	2
Asphalt	70	ACP Full Depth Reconstruction	0	15	25	66.50	73.00	72.00	71.00	70.00	66.50	25	15	100	56	3
Concrete	510	PCC Jnt Rehab & Crk Seal	80	82	100	6.50	7.25	7.00	7.00	6.75	6.50	25	15	83	2	11
Concrete	520	PCC Localized Rehab	70	73	80	14.25	16.50	16.00	15.75	15.25	14.25	25	15	85	16	10
Concrete	523	PCC Localized Rehab + Grind	70	73	80		16.50	16.00	15.75	15.25	14.25	25	15	85	16	9
Concrete	530	PCC Slight Pnl Rplcmnt (<10%)	60	63	70	29.00	35.00	34.00	33.00	32.00	29.00	25	15	88	31	7
Concrete	533	PCC Slight Pnl Rplcmnt (<10%) + Grind	60	63	70		35.00	34.00	33.00	32.00	29.00	25	15	88	31	7
Concrete	540	PCC Moderate Pnl Rplcmnt (< 20%)	50	54	60	44.50	56.50	54.50	52.50	50.50	44.50	25	15	90	41	5
Concrete	543	PCC Moderate Pnl Rplcmnt (< 20%) + Grind	50	54	60		56.50	54.50	52.50	50.50	44.50	25	15	90	41	5
Concrete	550	PCC Extensive Pnl Rplcmnt (<33%)	40	44	50	60.50	80.50	77.50	74.00	70.00	60.50	25	15	94	54	3
Concrete	553	PCC Extensive Pnl Rplcmnt (<33%) + Grind	40	44	50		80.50	77.50	74.00	70.00	60.50	25	15	94	54	3
Concrete	560	PCC Partial Reconstruction	25	30	40	82.50	104.50	101.00	97.50	93.00	82.50	25	15	96	66	1
Concrete	570	PCC Full Depth Reconstruction	0	15	25	121.00	161.00	155.00	148.00	140.00	121.00	25	15	100	84	2

Figure 13 – Rehab Unit Rates

**Unit rates vary slightly between functional classes*

Min PCI, Critical PCI, and Max PCI – These define the Pavement Condition Index (PCI) range applicable to the rehab selection. The Critical PCI defines when a segment is in its need year and is deemed to be critical, otherwise if deferred, the street declines in PCI past the point which the rehabilitation is no longer appropriate. Generally the Critical PCI falls 2 to 4 points higher than the minimum PCI applicable for each rehab activity.

Figure 14 graphically presents the application of pavement rehabilitations for asphalt streets by PCI. The Rehab numbers are simply placeholders that separate each rehabilitation project identified on the chart above. For example, Rehab 43 is an Moderate Overlay + Structural Patch.

Unit rates increase slightly between functional classes to reflect increase costs in pavement thickness, traffic control, and striping.

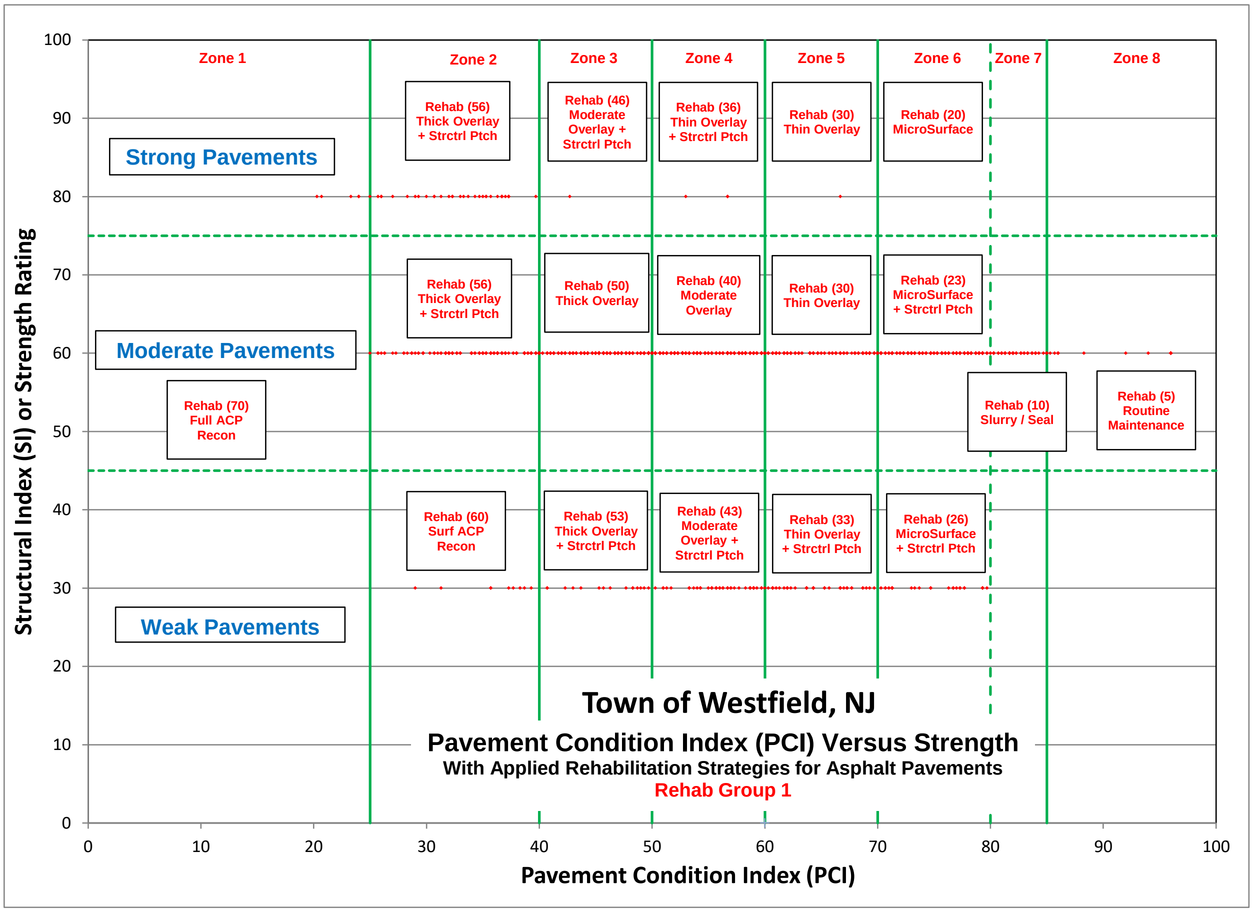


Figure 14 – Asphalt (ACP) Rehabilitation Strategies

Selection and Prioritization of Rehab Candidates

The Town's pavement management program incorporates a series of user defined values to prioritize and select the street segments for rehabilitation. The rehab selection order is not worst first, but rather designed to capture as many segments in their need year based on the incremental cost of rehab deferral. A Street is considered to be in its need year when it has reached its maximum service life and any further deferral would require a heavier and more costly rehabilitation. The rehab program has been designed to maximize the increased service life for each rehabilitation dollar spent on a segment.

Other factors included in the prioritization process focus on:

- **Need Year** – streets are only selected when they have expended their service life and are optimal for rehab selection.
- **Functional Classification** – generally priority is given to higher functional classifications as they provide greater benefits to a larger group of users
- **Pavement Strength** – weaker streets are prioritized higher than stronger ones as they deteriorate faster.
- **Area** – a very slight increase in priority is given to larger projects over smaller ones.

The net result is a program that favors thick overlays, followed by partial reconstruction projects then full reconstruction projects (more for safety reasons than cost-benefit). These are then followed by surface treatments and lastly by moderate to thin overlays.

The programmed deterioration curves illustrated in **Figure 15** are designed to integrate the pavement condition distribution performance curves for the network, with the applied rehabilitation strategies and their expected life cycle. Different color performance curves are meant to represent the full suite of curves assigned to segments based upon their functional class, pavement type, and strength.

It is important to recognize that even though all streets fall into specific rating categories and their respective rehabilitation strategies, it is not until a street falls to within a few points of the lower end of the range that it will become a critical need selected for rehabilitation.

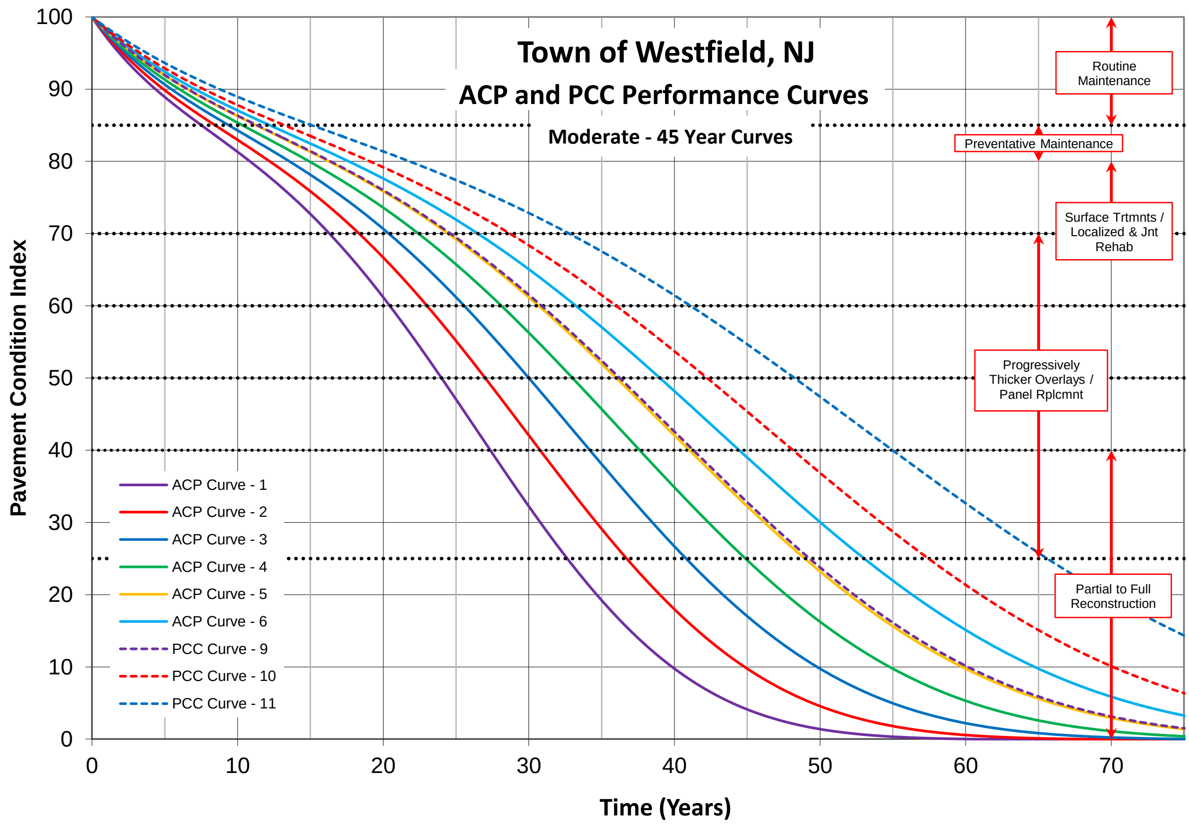


Figure 15 – Performance Curves

5.2 FIX ALL AND ANNUAL ESTIMATES

Three different approaches may be taken to identify and confirm the amount of funds the Town needs to set aside each year to maintain the roadway network at its current condition. All three are completed externally to the pavement management system and are simply used to validate the final results.

Option 1 – Estimated Life Cycle Cost Based on Network Value

An approximate value for the annual street maintenance budget may be quickly determined by taking the total value of Westfield's roadway network, estimated at $105M, and dividing that by the ultimate life of a roadway – approximated to be 50 years for asphalt and 75 years for concrete. By this method, the annual budget is estimated at $2,095,000.

Please note, the 50 to 75 year lifespan of the roadway is the theoretical life of the roadway surface from construction, until the point at which there not usable surface remaining, it is not simply the lifespan of the pavement surface until the next overlay.

Rehabilitation Estimate Based on Network Valuation

Pavement Type	Network Valuation ($)	Ultimate Life Span (yrs)	Life Cycle Cost ($/Yr)
Asphalt Network	104,655,000	50	2,093,000
Concrete Network	147,000	75	2,000
Town of Westfield, NJ Network Totals:	**104,802,000**		**2,095,000**

Option 2 – Estimated Life Cycle Cost Based on Current Condition

A second method to validate the annual budget is to identify the average network PCI and associated rehabilitation requirements, and then estimate the number of miles required to be rehabilitated each year based on a typical life cycle for that rehabilitation activity. For Westfield, the average PCI for asphalt roads is 66, which places the Westfield asphalt network in the Edge Mill + Thin Overlay range, at an average cost of $18.91/yd^2. Based on this estimate the Town needs to spend approximately $1,540,180/year to maintain the current condition average.

Rehabilitation Estimate Based on Network Average Condition

Pavement Type	Pavement Condition Index (PCI)	Rehab Code	Rehab Activity	Average Rehab Life Cycle (Yrs)	Miles to do Each Year	Blended Unit Rate ($/yd2)	Average Cost per Mile ($/)	Life Cycle Cost ($/Yr)
Asphalt Network	66	30	Edge Mill + Thin Overlay (1.5 - 2.0)	24	4.2	18.91	369,800	1,540,180
Concrete Network	93	5	Routine Maintenance	1	0.1	0.00	0	0
Town of Westfield, NJ Network Totals:								**1,540,180**

Option 3 – Estimated Life Cycle Cost Based on Network Deficiency

The third methodology to confirm the required amount of annual funding is to identify the current network deficiency, that is the amount required to rehabilitate all streets in the network assuming unlimited funding, and then divide by the typical life cycle of each rehabilitation activity. This is referred to as the Fix All Estimate and Life Cycle Cost. The rehab strategies listed in the table are generic in nature and not necessarily the final set that was applied to Westfield. For Westfield, the Fix All Estimate for the network deficiency is approximately $34M and the Life Cycle Cost is $1.3M/year, broken down as follows:

Town of Westfield, NJ

Rehabilitation Estimate Based on Current Network Deficiency and Life Cycle Cost

Rehab Code	Rehab Activity	Network Total ($)	% of Total	Town Arterial	Town Collector	Minor Street	Life Cycle (Yrs)	Life Cycle Cost ($/Yr)
10	Slurry Seal / Seal Coat	36,000	0.1	0	0	36,040	5	7,200
20	MicroSurface	0	0.0	0	0	0	8	0
23	MicroSurface + Strctrl Ptch	1,709,100	5.0	0	327,540	1,381,550	8	213,600
26	MicroSurface + Strctrl Ptch	0	0.0	0	0	0	8	0
30	Edge Mill + Thin Overlay (1.5 - 2.0)	4,910,100	14.4	159,390	1,393,290	3,357,430	24	204,600
33	Edge Mill + Thin Overlay (1.5 - 2.0) + Strctrl Ptch	522,300	1.5	323,930	198,350	0	24	21,800
36	Edge Mill + Thin Overlay (1.5 - 2.0) + Strctrl Ptch	63,100	0.2	0	0	63,120	24	2,600
40	EM/FWM + Moderate Overlay (2.0 - 3.0)	17,192,800	50.6	0	3,458,540	13,734,270	30	573,100
43	EM/FWM + Moderate Overlay (2.0 - 3.0) + Strctrl Ptch	1,622,600	4.8	0	426,120	1,196,430	30	54,100
46	EM/FWM + Moderate Overlay (2.0 - 3.0) + Strctrl Ptch	52,200	0.2	0	0	52,220	30	1,700
50	FWM + Thick Overlay (> 2.0 - 3.0)	6,066,700	17.8	0	997,970	5,068,770	37	164,000
53	FWM + Thick Overlay (> 2.0 - 3.0) + Strctrl Ptch	0	0.0	0	0	0	37	0
56	FWM + Thick Overlay (> 2.0 - 3.0) + Strctrl Ptch	1,823,900	5.4	0	0	1,823,930	37	49,300
	Town of Westfield, NJ Network Totals:	**33,998,800**		**483,320**	**6,801,810**	**26,713,760**		**1,292,000**

5.3 NETWORK BUDGET ANALYSIS MODELS

An analysis containing a total of 10 profile budget runs plus a Do Nothing options was prepared for Westfield.

The analysis results are summarized below:

- **Do Nothing** (illustrated in **Figure 18**) – This option identifies the effect of spending no capital for 5 years. After 5 years, this scenario results in a network average PCI drop from a 66 to a 57 and a dramatic increase in backlog to 23%.
- **Westfield Budget** (Green Line) – this represents the Town's current annual budget of $1.8M annually dedicated to pavement preservation and rehabilitation. This level of funding will result in a network average PCI score of 70 and a backlog reduction of 12%.
- **Steady State PCI** – this is simply the funds required to maintain the current network average PCI at a 66. The annual budget required to do so is on the order of $1.87M annually, however backlog (Very Poor & Poor roadways) continues to climb to 15%.
- **Backlog Control Budget** – A budget designed to maintain the Town's current backlog at 10%.

The results of the analysis are summarized in **Figure 16** below. The X-axis highlights the annual budget, while the Y-axis plots the 5 Year Post Rehab Network Average PCI value. The diagonal blue line is the results of the pavement analysis (the Westfield model profile).

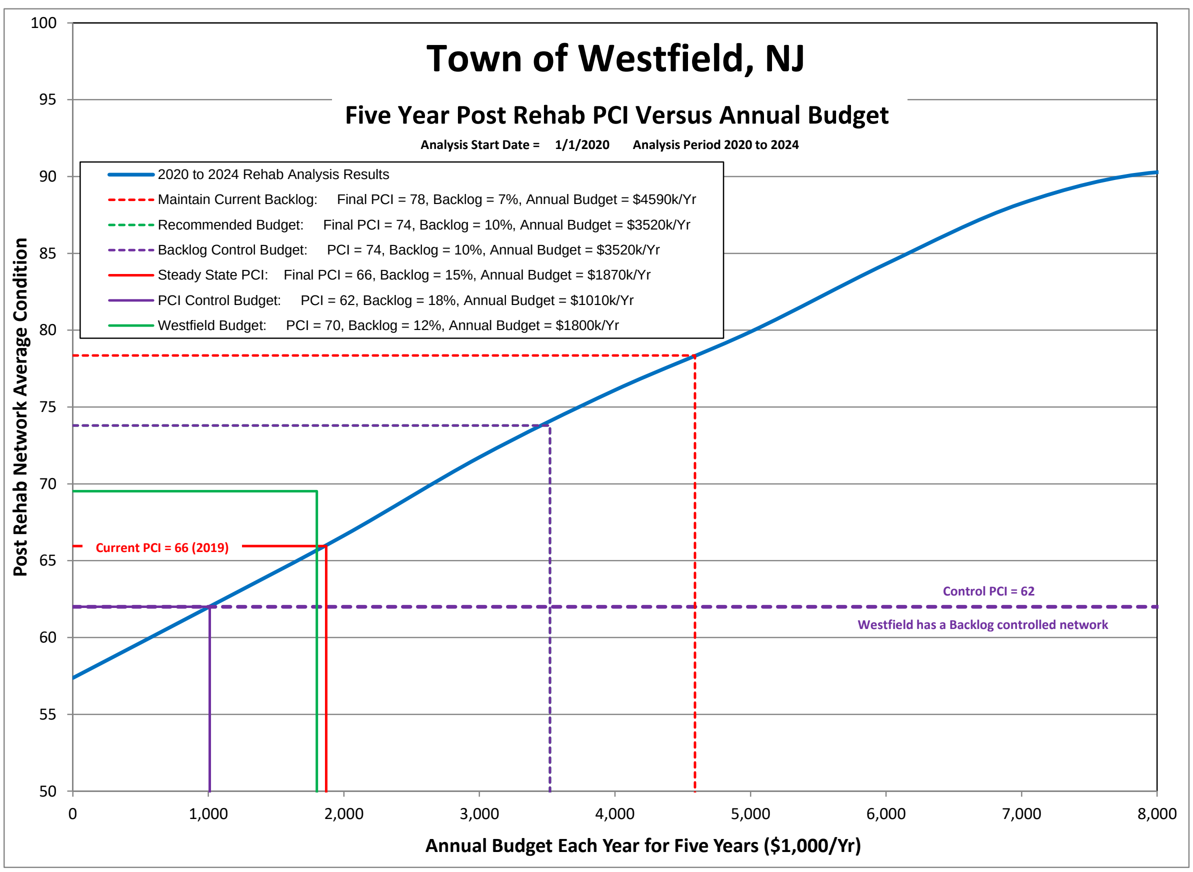


Figure 16 – 5 Year Post Rehab Network PCI Analysis Results

Figure 17 presents the resultant network backlog against annual budget. Similar to **Figure 16**, but instead of plotting the average PCI score, the blue diagonal line represents the total backlog after 5 years.

The lower the backlog the better, with a maximum of 12% recommended

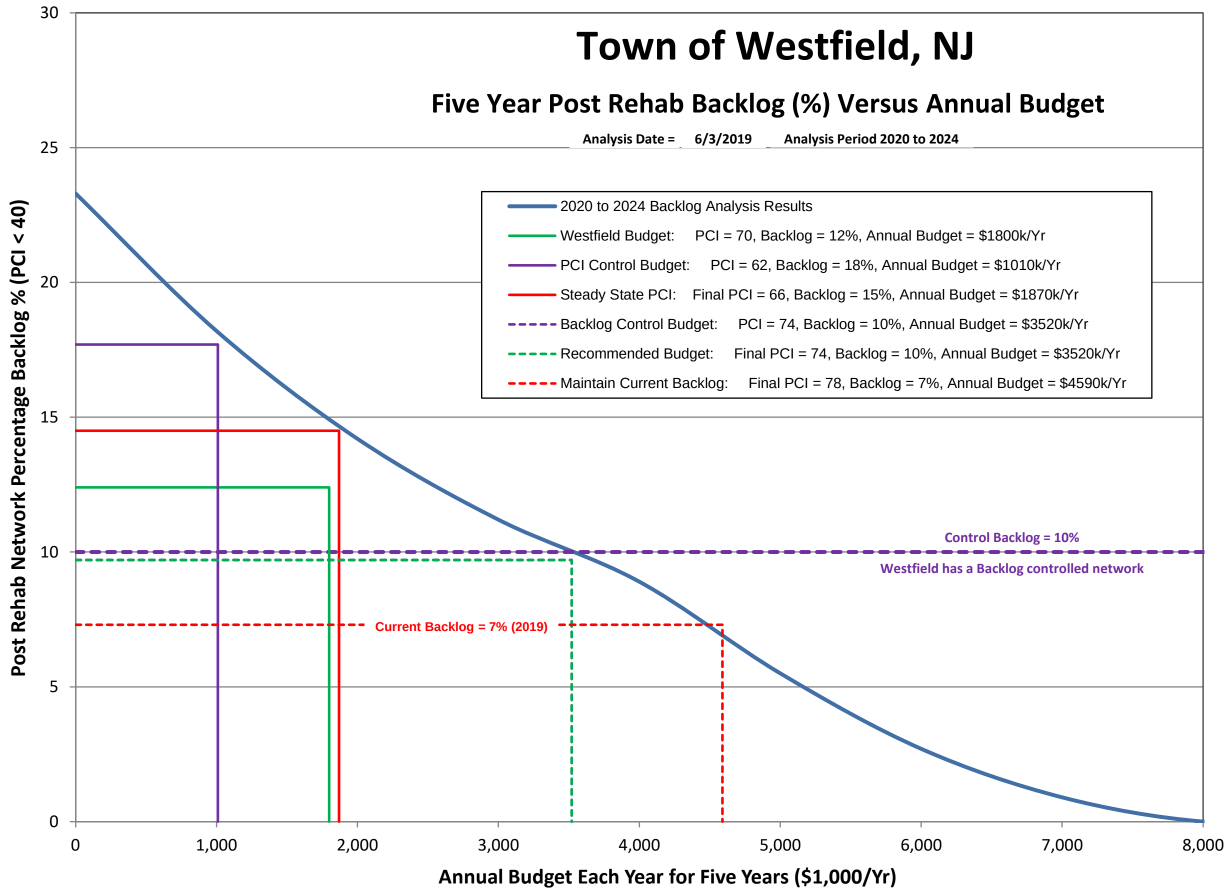


Figure 17 – 5 Year Post Rehab Network Backlog Results

Figure 18 presents the analysis results on an annual basis. This shows that if the budget falls below $1.8M/year (Steady State Budget), over time the overall condition of the roads will deteriorate as backlog continues to grow.

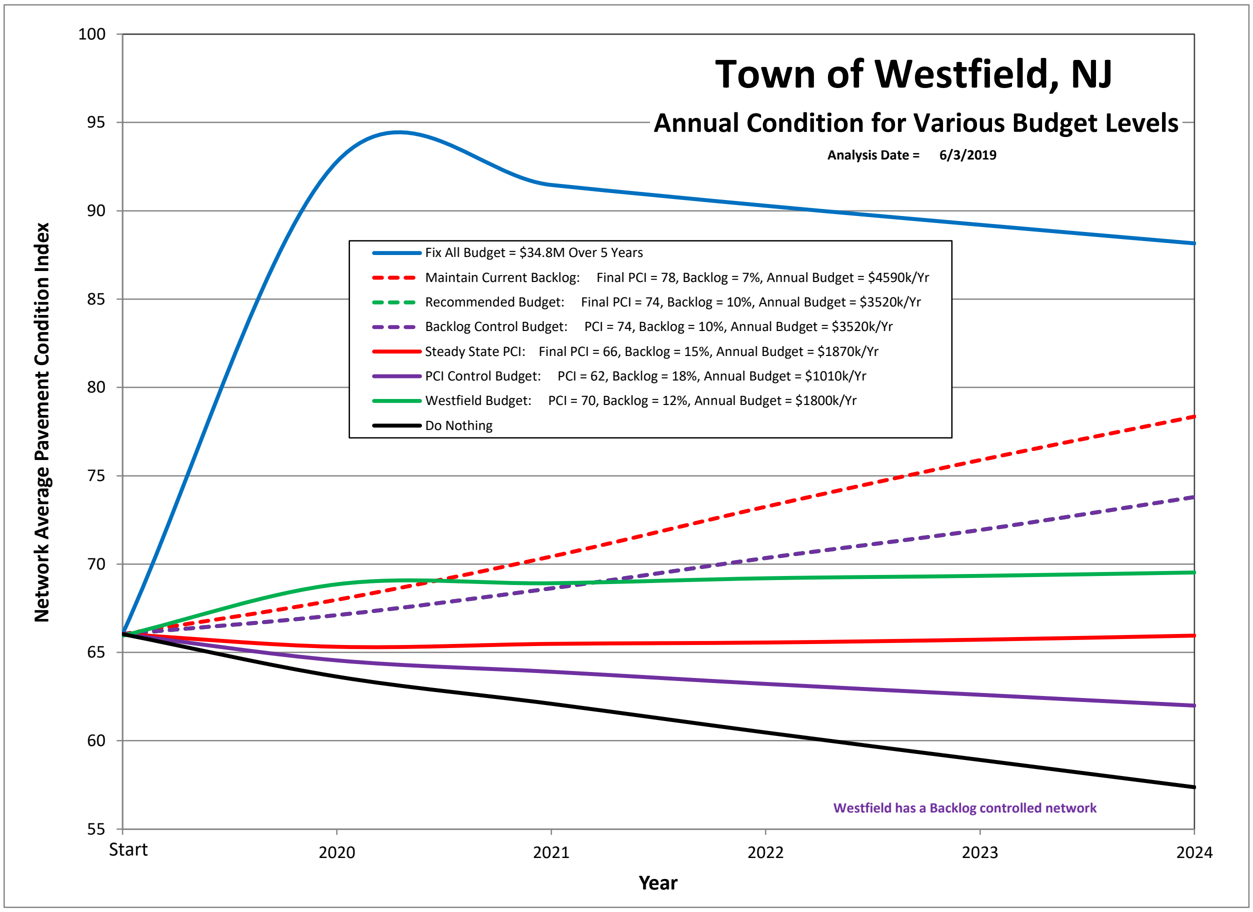


Figure 18 – 5 Year Annual PCI

5.4 POST REHABILITATION CONDITION

The following figure (**Figure 19**) compares the current network condition distribution (red) against what the 5-year post rehabilitation distribution would be at with a budget of $1.8M/year (blue). As can be seen in the plot, the Westfield budget will increase the overall network's PCI average and increase the amount of roads rated as excellent.

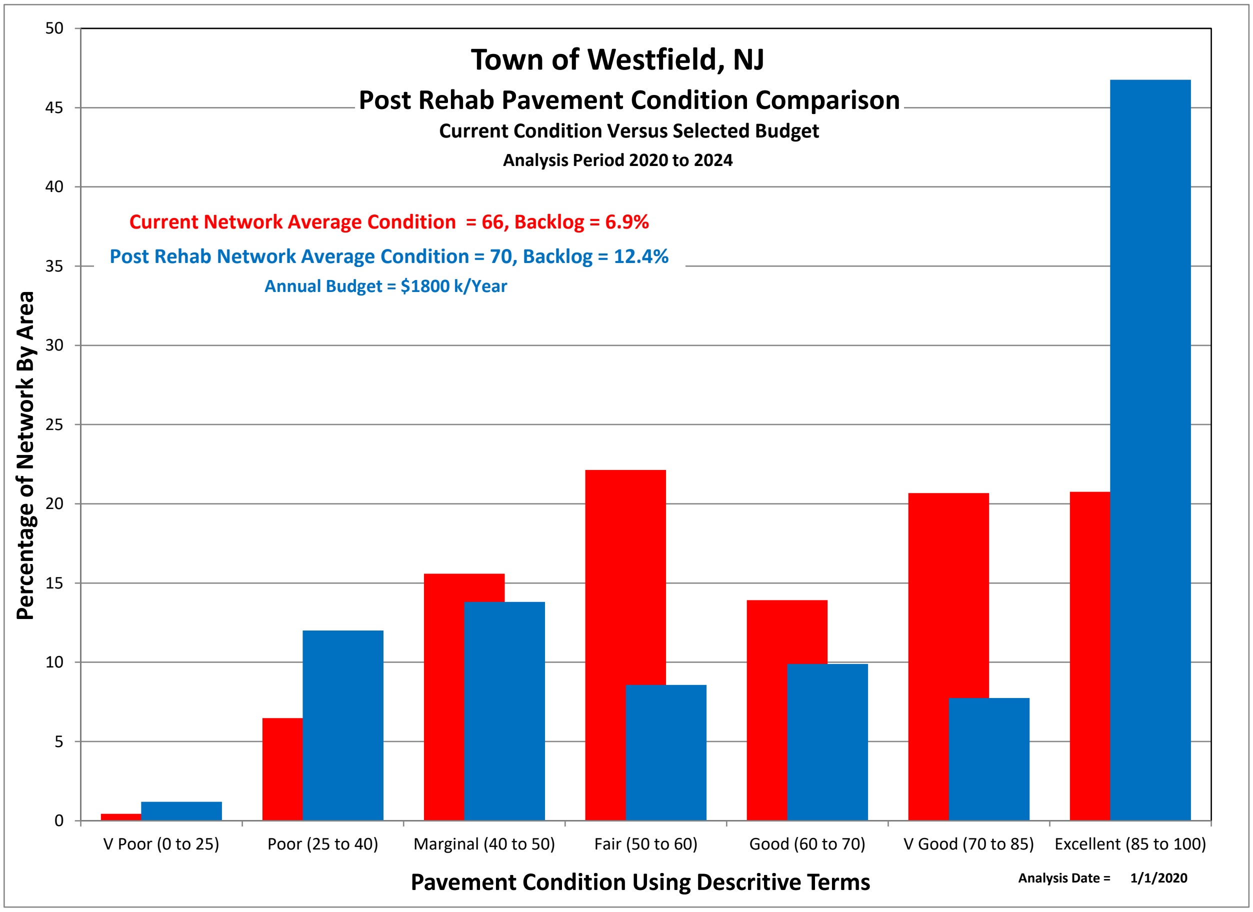


Figure 19 – Five-Year Post Rehabilitation Condition Distribution

Three metrics are used to evaluate the quality of a roadway network, they are:

Average Condition – should be between 60 and 65 at a minimum
Percentage of Backlog – target 12%, should be less than 15%, must be less than 20%
Percentage of Streets Rated as Excellent – should be greater than 15%

5.5 NETWORK RECOMMENDATIONS AND COMMENTS

The following recommendations are presented to Westfield as an output from the pavement analysis.

1. Westfield should adopt a policy to maintain PCI at or above a 70 while keeping backlog below 15%.

An annual budget of $1.8M (dedicated to pavement rehabilitation) will achieve a network average PCI of 70 and backlog of 12%.

2. The full suite of proposed rehabilitation strategies and unit rates should be reviewed annually as these can have considerable effects on the final program.
3. No allowance has been made for network growth. As the Town expands or increases the amount of paved roads, increased budgets will be required.
4. No allowance has been made for routine maintenance activities such as asphalt crack sealing, pothole filling, sweeping, striping or patching within the budget runs and analysis. These costs are assumed to be outside the pavement management costs.
5. The Town should resurvey their streets every few years to update the condition data and rehabilitation program.

Appendix A

Full-Sized Maps

town of
WESTFIELD
NEW JERSEY
Pavement Survey
Functional Classification
by Segment
Legend
Functional Class
Town Arterial
Town Collector
Minor Street
Town Boundary
NORTH
0
0.25
0.5
Miles


town of
WESTFIELD
NEW JERSEY
Pavement Survey
Pavement Condition Index (PCI)
Current PCI by Segment
Labels
1234 GISID
1234 Project ID
Legend
PCI
11 - 20 red
21 - 30
31 - 40
41 - 50
51 - 60 yellow
61 - 70
71 - 80
81 - 90
91 - 100 green
Town Boundary
NORTH
0
0.25
0.5
Miles
78
22
28
Lake Surprise
Blue Brook
Watchung Reservation Pond
Echo Lake
Nomahegan Brook
Lenape Brook
Lenape Park Pond
Nomahegan Park Lake
Fairview Cemetery Pond
Brightwood Park Pond
Garwood Brook
Tamaques Reservation Pond
Rahway River
Pumpkin Patch Brook
Stream
WOODLAND AVE
GALLOWS HILL RD.
N. CHESTNUT ST.
LAWRENCE AVE
BRIGHTWOOD AVE
DUDLEY AVE. E.
N. EUCLID AVE
PROSPECT ST
ELM ST
CLARK ST
DUDLEY AVE. W.
E. BROAD ST.
S. CHESTNUT ST.
FOURTH AVE
ELMER ST
CONRAIL RAILROAD
N. SCOTCH PLAINS AVE
SCOTCH PLAINS AVE
DORIAN RD.
PARK ST.
BOULEVARD
WESTFIELD AVE
GROVE ST. E.
GROVE ST. W.
SYCAMORE AVE
CLOVER ST.
RAHWAY AVE
WILLOW GROVE RD
CUMBY AVE